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44TH CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, pt. 2, vol. II.

ANNUAL REPORT

OF THE

CHIEF OF ENGINEERS

31247

TO THE

SECRETARY OF WAR

FOR THE

YEAR 1876.

IN THREE PARTS.

PART I.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1876.

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ERRATA.

[Annual Report of the Chief of Engineers for 1876, Part I, Appendix F.]

Page 284, line 2, strike out "of" and insert "at."
Page 292, line 20, strike out "our" and insert "an."
Page 293, line 20, strike out "no" and insert "an."
Page 295, line 27 from bottom, strike out "15" and insert "50."
Page 296, table of characteristics, fourth column, strike out "1,011" and insert "11,011."
Page 296, table of characteristics, fourth column, strike out "6,226" and insert "622.6."
Page 296, table of characteristics, first column, strike out "$\frac{a}{W \times p}$" and insert "$\frac{a}{W + p}$."
Page 296, table of characteristics, second column, strike out "606" and insert "3,606."
Page 296, formula, 3 lines below table, in denominator of last term, strike out "$1 \times p$" and insert "$1 + p$."
Page 296, 5 lines below table, strike out "p" and insert "h."
Page 296, 6 lines below table, strike out "p" and insert "h."
Page 297, line 6, strike out "Farrae's" and insert "Farrar's."
Page 297, line 23, formula, strike out minus sign in numerator, so as to read, "$h = \frac{r^2 N \sin 30^\circ}{256.3}$."
Page 297, line 49, formula, strike out "v" and insert "r," so as to read, "$S = \left(\frac{(r^{\frac{1}{2}} + 0.0338)^4}{225r}\right)^2$."
Page 298, line 16 from table, strike out "just" and insert "first."
Page 300, line 34, after "when" insert "first."
Page 315, line 31, strike out "juncture" and insert "junction."
Page 316, line 41, strike out "closing" and insert "clearing."
Page 322, line 26, strike out "of" and insert "for."
Page 323, line 32, strike out "probable" and insert "favorable."
Page 325, line 16, after "in" insert "September."
Page 325, line 21, strike out "Zeke's" and insert "Smith's."
Page 326, line 36, after "the" insert "line of."
Page 326, line 55, after "mark" insert: "As it was, eight cribs, constituting 160 feet of work, settled so much that the expedient of sinking top-cribs upon them had to be resorted to. This settling was checked by sinking large quantities of brush, loaded with stone, on the sides, at the end, and in the spaces between the cribs, (where any existed,) and finally the settling ceased, and the whole 500 feet remained intact. The beach at Federal Point followed out quite rapidly on each side of the jetty, and on the completion of the 500 feet at least one-third of the work was covered to high-water mark."
Page 327, line 46, inclose in parenthesis the following sentence: "the steam for the same being supplied by the boiler of the steamer."
Page 327, line 46, after "steamer" and parenthetical sign insert: "with connecting suction and discharge pipes. Sand-bins were constructed upon the main deck of the steamer." The whole (including line 46) to read: "(the steam for the same being supplied by the boiler of the steamer,) with connecting suction and discharge pipes. Sand-bins were constructed upon the main deck of the steamer."
Page 327, line 61, strike out "have" and insert "had."
Page 328, lines 33 and 34, strike out "naturally" and insert "mutually."
Page 328, line 34, strike out "construction" and insert "contraction."
Page 329, line 19, strike out "lightening" and insert "lightering."
Page 329, line 38, strike out comma after "used" and insert period.
Page 329, line 38, after "used" insert: "Bidders were to be allowed much latitude in their proposals, and were invited to propose the class of material to be used."
Page 330, line 61, after "of" insert "this."
Page 331, line 14, strike out "quantities" and insert "quantity."

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[EXTRACT FROM THE ANNUAL REPORT OF THE SECRETARY OF WAR.]

WAR DEPARTMENT, *November* 20, 1876.

* * * * * * *

ENGINEER DEPARTMENT.

The report of the Chief of Engineers states that work has progressed satisfactorily upon our sea-coast defenses, and as much has been accomplished as the limited appropriation would permit. It is recommended that heavy guns should be mounted in covered positions along the inlets to our harbors, as the basis of successful defense, and as being essential to the efficiency of torpedoes as channel obstructions. The trials with torpedoes at Willet's Point have been continued with satisfactory results. As much of the material for the torpedo system cannot be obtained in an emergency, the Chief of Engineers has asked for an appropriation of $150,000 to procure and store such parts of the apparatus as would be immediately required in the event of sudden hostilities.

Works for the improvement of rivers and harbors, and the surveys and examinations connected therewith, have progressed satisfactorily during the fiscal year. The amounts appropriated by the river and harbor act of March 3, 1875, were applied to the specific objects therein designated. The removal by blasting of a portion of Hallet's Point, in East River, New York, which forms part of the operations in progress for the improvement of the navigation of Hell Gate, was successfully accomplished in September last without accident.

To carry into effect the act of March 3, 1875, for the further security of navigation on the Mississippi, which directed an inquiry to be made of the expense of causing sheer-booms to be placed on the upper end of any or all bridges on the river, for the better security and convenience of navigation, a board of officers of the Corps of Engineers has been constituted, and is now engaged upon the consideration of the subject.

Of the amounts appropriated for public works on the rivers and harbors by the act of August 14, 1876, I directed allotments to be made, so as to limit the expenditure for those objects to $2,000,000, and at the same time directed that no new works be begun. This amount has been increased by subsequent allotments to $2,237,600, and the works are now being conducted on that basis.

The various surveys under the Engineer Department have made good progress during the year, although somewhat crippled by small appropriations.

In the elaborate survey of the lakes the field-work on Lake Ontario and the Niagara River has been completed. On Lake Erie the triangulation has been carried west to Westfield, and the topography and hydrography west to the Welland Canal, in the north, and to Ashtabula on the south shore. Lines of levels have been run from Albany to Oswego, and from Port Dalhousie to Port Colburn. Determinations of latitude and longitude have been made at ten points in aid of State

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surveys. Five of the series of detailed charts of the lakes have been completed during the year, and eight charts have been printed and distributed in aid of the great commerce of those waters.

Two volumes of the report of the geological exploration of the fortieth parallel have previously been published and distributed, and the remaining volumes are now ready for the Public Printer, together with copies of the atlas sheets and other illustrations.

In the engineer survey of the Territories west of the one hundredth meridian, progress has been made in Colorado, California, Nevada, New Mexico, and Arizona. Of the report, volumes III and V and part of volume IV have already been printed. Volume II and the second part of volume IV are now ready for the Printer, and the others are in an advanced state of preparation. Seven topographical maps, representing about 17,000 square miles each, and six geological sheets have been published. The examination of the river Colorado, with the design of determining the feasibility of its diversion for purposes of irrigation, has been completed, and the report thereof will be found in the report of the Chief of Engineers. It is hoped that Congress will recognize the desirability of a regular progress of this very useful survey, and will provide ample appropriations for that purpose.

No little embarrassment has been caused during the current year by the failure of the appropriation for surveys by the engineer officers stationed at headquarters of the various military divisions and departments. These officers collect geographical and other information in their own reconnaissances and those of line officers on scouts and campaigns, and have at very little expense produced reports and maps of the highest utility, not only to the commanding generals, but to the public at large. This work is now entirely stopped by the failure of the appropriation and the consequent discharge of draughtsmen and other persons employed. Unless further appropriation is made a large mass of valuable material in the form of notes and sketches, now ready to be incorporated into reports and maps, must remain in its present useless form. It is urgently hoped that the estimate for this work will receive favorable attention from Congress.

* * * * * * *

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REPORT

OF

THE CHIEF OF ENGINEERS.

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REPORT

OF

THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 21, 1876.

SIR: I have the honor to present for your information the following report, upon the duties and operations in the Engineer Department, during the fiscal year ending June 30, 1876:

OFFICERS OF THE CORPS OF ENGINEERS.

The number of officers holding commissions in the Corps of Engineers, United States Army, at the end of the fiscal year, was 107 on the active-list, and 5 on the retired-list; the latter, however, under the law of January 21, 1870, not being available for duty. In the duties devolving upon the corps by law, and its organization, the employment of a number of scientists and assistant engineers has been necessary.

The only change in the officers of the corps since my last report, is the resignation of Capt. Asa H. Holgate, December 9, 1875.

On the 30th of June, 1876, the officers were distributed as follows:

On duty, office of the Chief of Engineers, including chief	4
On duty, projection and construction of fortifications	7
On duty, construction of fortifications and light-house duty	2
On duty, construction of fortifications, and river and harbor works, and surveys for same	18
On duty, construction of fortifications and river and harbor works and light-house duty, and surveys for same	4
On duty, construction of river and harbor works, and surveys for same	15
On duty, construction of river and harbor works and light-house duty, and surveys for same	5
On duty, survey of northern and northwestern lakes	7
On duty, explorations of country west of one hundredth meridian	3
On duty with battalion of engineers	14
On duty, public buildings and grounds, District of Columbia	1
On duty under Board of United States Executive Departments, collecting and arranging articles pertaining to Engineer Department for the International Exhibition, 1876	2
On sick-leave	1
Detached on duty with the Secretary of War, the General of the Army, generals commanding divisions and departments, light-house establishment, Military Academy, survey of northern boundary-line under Department of State, and the Board of Commissioners of the District of Columbia	23
Awaiting orders	1
Total	107

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The officers detached were on duty as follows:

Col. I. C. Woodruff, engineer third light-house district	1
Lieut. Col. William F. Raynolds, engineer fourth light-house district	1
Lieut. Col. R. S. Williamson, engineeer twelfth light-house district	1
Maj. O. M. Poe, on staff of the General of the Army	1
Maj. F. Harwood, engineer fifth light-house district	1
Maj. P. C. Hains, engineer-secretary to the Light-House Board	1
Maj. G. L. Gillespie, on staff of Lieutenant-General commanding Military Division of the Missouri	1
Capt. William A. Jones, engineer sixth light-house district	1
Capt. William S. Stanton, on staff of commanding general Department of Platte	1
First Lieut. E. H. Ruffner, on staff of commanding general Department of the Missouri	1
First Lieut. J. C. Mallery, on staff of major-general commanding Military Division of the Pacific	1
First Lieut. Edward Maguire, on staff of commanding general Department of Dakota	1
First Lieut. R. L. Hoxie, chief engineer of the District of Columbia, under the direction of the board of Commissioners	1
First Lieut. F. V. Greene, on duty in the office of the Secretary of War	1
Capts. William J. Twining and J. F. Gregory, on duty under Department of State, upon joint commission for the survey of the boundary-line along the forty-ninth parallel	2
Capts. C. W. Raymond, A. M. Miller, T. H. Handbury; First. Lieuts. J. G. D. Knight, S. E. Tillman, C. F. Palfrey, and William H. Bixby, on duty at the Military Academy	7
Total	23

The following principal geologist and civil engineer were employed on the 30th of June: Clarence King, geologist, in charge of geological exploration of the fortieth parallel; and S. Thayer Abert, in charge of river and harbor improvements on Potomac River and Chesapeake Bay.

SEA-COAST AND LAKE-FRONTIER DEFENSES.

During the past year the work upon our sea-coast defenses has progressed as rapidly as good workmanship and the amount of the appropriations granted would permit.

The close of the late civil war found the naval armaments of maritime nations provided with new and powerful devices, which they had not possessed prior to the experiences of that conflict.

Iron-plated ships, invulnerable to shells, propelled by powerful engines, armed with rifled ordnance of large calibers, and capable of navigating the ocean, were the outgrowth of the period of our late civil war.

The sea-coast works of that day, for defense against and resistance to naval armaments, had been proportioned and constructed for armaments of much less weight and power than those now in existence—and the safety of our commercial cities, navy-yards, and war depots required that the sea-coast defenses existing in 1865–'66 should be materially strengthened by the enlargement in some cases of their parts, the addition of other works, the adoption of some new appliances, and the introduction of heavier armaments.

After a careful study of the subject by the Corps of Engineers, and with the light afforded by the experience of actual conflict between sea-coast defenses and the new naval armaments, the system to govern the future construction of our works was elaborated in 1869, and will be found stated in detail in Executive Document No. 271, House of Representatives, Forty-first Congress, second session, where it will be seen the system received the approval of the General of the Army and the Secretary of

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War, and since then has been repeatedly endorsed by the action of Congress.

The main features of this system are the use of heavy earthen barbette batteries, with parados and traverses, of heavy mortar-batteries, and of obstructions in the channels, (mainly electrical torpedoes,) to hold vessels from running past the batteries and reaching the cities or depots beyond them.

Works of this character have been steadily progressing since 1869, and in many of our harbors are well advanced towards completion, but in none of the harbors are these alterations finished, while in some of our important harbors along the Gulf-coast the works are scarcely commenced.

Regarding the pressing necessity for the completion of the works in advance of hostilities, I beg leave to quote from my remarks of last winter to the Military Committee of the House of Representatives, contained in report No. 354, House of Representatives, Forty-fourth Congress, first session, pages 179 and 180:

In the event of war with a maritime nation, if we had no well-digested system of sea-coast defense ready for use, the cruisers and war-vessels of the enemy could run into our harbors, and without landing could either destroy the property along the shores or else lay the people under contribution. The accurate detailed charts of our harbors and channels, published by the United States Coast Survey, are accessible to all such nations, and are doubtless in their possession. If the enemy possesses depots and arsenals in close proximity to our shores, the arrival of such armed vessels will follow in a few hours after the declaration of war. Thirty-six hours' steaming could bring vessels from Halifax; six hours, vessels from Havana, and ninety-six hours, vessels from Victoria, Vancouver's Island, to important harbors of the United States. There might be very little time for preparation to meet the assaults of iron-plated ships, for they are plated with from 6 to 15 inches of iron, and carry rifled guns from 9 inches to 14 inches bore, all of which guns are more powerful than any gun we have in our service. With a fleet or even a single vessel of this kind in one of our harbors it would be of no avail to collect troops in the city or town threatened. Suppose with our railroad facilities we could concentrate 100,000 men in twenty-four hours at the point threatened, of what use would they be against the armored ship? Suppose that in a night the men concentrated could throw up earthworks and mount 32-pounders, 42-pounders, 100-pounder rifles, (even if it were possible to handle guns of this small size with the rapidity assumed,) what injury could all this do to the armored ship in question? The projectiles from such batteries would fall harmlessly from the side of the enemy. While lying, if need be, beyond the range, even, of our guns, with his more powerful armaments he would pierce such parapets through and through, dismount the guns, and explode such magazines.

But it may be said that we would mount guns as powerful and even more powerful than those of the enemy. Doubtless this would be done, first, if we had such guns in our service, and, second, if we had the time.

Our largest gun, of which we have any number, is a 15-inch smooth-bore, and weighs over 25 tons. We have about 325 of them for our entire coasts of 12,600 miles, exclusive of Alaska, and beyond a range of 1,200 yards it is a less powerful gun than the 9-inch rifle of 12 tons. The 10-inch rifle weighs 18 tons, the 11-inch 25 tons, the 12-inch 35 tons, and the 14-inch 81 tons, and these guns are immeasurably superior to our 15-inch smooth-bore. They are the kinds of guns we must mount in batteries against the iron-plated vessels. But their great weight and size require corresponding dimensions in the batteries in which they are placed and in the strength and solidity of the platforms upon which they are mounted. The parapets and traverses of earth and sand to protect them must be three and even four times as thick and massive as they were formerly built to resist the armaments of fifteen years ago. Where the parapets of earth were but 10 feet in thickness, now they must be 40 feet. Guns that were formerly dragged with ease by fifteen or twenty men and placed in position over night are now supplanted by armaments of such huge masses that special mechanical appliances are required to move them even slowly, and cannot be lifted upon their supports without the aid of hydraulic power. No matter how many men may be at our disposal, the time required to place the modern armaments in position is vastly greater than for the guns of fifteen years ago; and before such works could be improvised in a harbor the enemy in his iron-clads will have accomplished all he desired and have sailed or steamed for some other harbor to repeat the injuries of the first. But suppose the harbor in question was on the New England coast, and the season of the year the winter, when

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the ground is frozen hard, then the erection of efficient earthen batteries would be out of the question; or suppose the harbor was on the Gulf-coast, and the season the fall of the year, when only the acclimated could resist the effects of the malarial shores, under such circumstances the erection of efficient batteries would be exceedingly difficult.

* * * * * * *

Our country is contiguous throughout its northern boundary with the most powerful maritime power of the earth, and close upon our southern shores is another, whose strength is not to be despised. These are the nations with whom complications are most likely to arise.

Many of our works are in an unfinished, transition state; our supplies of torpedo materials are insufficient; the caliber and force of our guns are too small, and under these circumstances I must reiterate, the work on our sea-coast fortifications should not be suspended.

Repeating these views, and impressed by the importance of the subject, involving, as it does, such great national interests, I again urge the preparation of our harbors for successful resistance against the incursions of the powerful iron-clads of the present day.

For detailed report upon the several works of fortification, I beg leave to refer to the synopsis of reports of the several officers in charge. The estimates for the works have been carefully revised by me and are earnestly recommended.

Special attention is asked to the estimate of $150,000 for torpedoes. This most valuable invention of modern warfare is used to form an obstruction and obstacle to the entrance of our harbors, and to hold the enemy's vessels under the fire of the shore batteries. The charges in the torpedoes are fired by the electric current, and many parts of the system cannot be obtained in an emergency. It is to procure and store such portions of the apparatus as cannot be speedily obtained in the event of sudden hostilities that the appropriation is asked.

FORTIFICATIONS.

Fort Wayne, Michigan, in charge of Lieut. Col. C. E. Blunt, Corps of Engineers.—This work commands the channel of Detroit River, and with its exterior barbette batteries already planned, will control the navigation of that stream.

The brick scarps of this work need extensive pointing and repairs, the latter made necessary by insufficient drainage. These matters have not been taken in hand for want of funds, nor can they be this season for the same reason.

The rebuilding of the fences around the reservation, and the regrading of the grounds along a part of the boundary-line, were reported last year as half finished and in progress. This work was completed in August, 1875, at a cost of $2,011.28 allotted from the appropriation for contingencies of fortifications. No preparations have been made or are intended for any change in the armament of the work.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Porter, Black Rock, near Buffalo, N. Y., in charge of Lieut. Col. C. E. Blunt, Corps of Engineers.—This work occupies an important strategic point for the defense of the northern frontier. It remains the same as last reported, except additional adornment of the grounds by the city of Buffalo, under act of Congress approved July 11, 1870. Nothing has been done by the United States upon the fort during the past year, and nothing is proposed for the present fiscal year, there being no funds available. No preparations have been made or are intended for any change in the armament.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

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Fort Niagara, mouth of Niagara River, New York, in charge of Maj. John M. Wilson, Corps of Engineers until December 1, 1875; *since that date in charge of Maj. Walter McFarland, Corps of Engineers.*—This work is situated at the mouth of the Niagara River, commanding its *debouch* into Lake Ontario.

This work remains in the same condition as at the close of the last fiscal year. The main approach to it has been damaged by water, but is in the course of repair.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Ontario, mouth of Oswego River, New York, in charge of Maj. John M. Wilson, Corps of Engineers, until December 1, 1875; *since that date in charge of Maj. Walter McFarland, Corps of Engineers.*—This work protects the city of Oswego from a sudden attack or *coup de main*, or the levy of a contribution by a small force of an enemy on shipboard.

This work remains in the same condition as at the close of the last fiscal year. No work has been done, and no money expended upon it, except for minor repairs and pay of watchman. Nothing has been done toward preparing this work for its armament.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Montgomery, outlet of Lake Champlain, New York, in charge of Lieut. Col. John Newton, Corps of Engineers.—This work occupies an important strategic point, and commands the entrance to Lake Champlain from the Richelieu or St. John River. During the year the parade was graded as far as practicable, new bridge constructed and placed in the main postern, and the repair of the causeway, together with the sodding of parapet of curtain, (3,) has been commenced. Six hundred yards of earth and gravel were employed in grading parade.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Knox, Bucksport, Penobscot River, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work, situated at the narrows of the Penobscot River, furnishes a defense for the city of Bangor and other towns bordering the Penobscot, and renders the river available as a secure harbor of refuge for the shipping of the extensive eastern seacoast.

The condition of this work remains unchanged, no operations having been carried on during the past fiscal year, except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Popham, Kennebec River, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work defends the entrance through the mouth of the Kennebec River to the rich valley of this river, the cities of Bath and Augusta, and the United States arsenal at the latter place.

The condition of this work remains unchanged, no operations having been carried on during the past fiscal year, except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Gorges, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work is one of the series of forts designed to defend the harbor and channels leading into the harbor of the important strategic position occupied by the city of Portland.

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The operations of the past fiscal year consisted in leveling the parade and covering it with loam, building the balcony on the gorge parade-wall and the guard-railing of this and the parade-wall of front 1, iron-plating and hanging the parade-gates of the main entrance, and completing the flooring and finishing of all the quarters in the gorge.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year to complete the work..... $10,000

Fort Preble, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work occupies such a position that three-fourths of its guns command the two principal channels entering the harbor of Portland.

Since the close of September no work has been done for want of sufficient funds. At that time four new breast-height walls and three new gun-platforms had been built in the south battery and the sodding of the parapet essentially finished.

In the north battery the roadway was completed in rear and about the westerly extremity of the parados.

This work has now reached an advanced state toward completion, and but little time or money is needed to finish and place it in a condition of efficiency for many years to come.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year to complete the work..... $30,000

Fort Scammel, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work occupies a very important position in the harbor, and commands four of the channels leading into it.

The operations of the past fiscal year were carried on only during the first four months, the funds being then nearly exhausted. The sally-port extension and the second passage to the new extension of the main work were built in concrete. Two gun-platforms and all of the traverse and parados embankments of the old portion of the main work were completed and the parade graded.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $50,000

Battery on Portland Head, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work covers by its guns all the approaches to the main channel leading into the harbor, and will prevent by its fire an enemy's fleet from taking up, unopposed, a position behind Bangs's Island, from which to bombard Portland, or shell the shipping in the harbor.

Work was carried on only during the first four months of the past fiscal year, and has not since been resumed for want of funds. The embankments of the parapet and traverses of front 1 were nearly completed by grading and sodding, and the three breast-height walls, six gun-platforms, and two of the traverse-magazines were built. A portion of the breast-height wall was built in bay No. 5.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $50,000

Fort McClary, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work, together with Fort Constitution opposite, forms the inner line of defense to the mouth of the Piscataqua River, and to the navy-yard at Kittery, Me.

The condition of this work remains the same as at the close of the previous fiscal year; no operations having been carried on except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

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Fort Constitution, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—The condition of this work remains the same as at the close of the previous fiscal year, no operations having been carried on except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Battery on Gerrish's Island, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This battery, with the one opposite, on Jerry's Point, forms the outer line of defense to Portsmouth Harbor, and to the navy-yard at Kittery, Me.

This work has reached an advanced state of completion. During the past fiscal year the remaining five breast-height walls were finished and the gun-platforms were built, except laying the irons. Operations were closed in September last, and not since resumed for w ant of funds.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year to continue the battery $36,000

Battery on Jerry's Point, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—Operations were carried on from the beginning of the past fiscal year until October 15, and have not since been resumed for want of funds. Two traverse-magazines were built, the foundation for a third was laid, and over 2,000 cubic yards of embankment made.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year to continue the battery..... $24,000

Fort Warren, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—This important work is for the defense of the main channel of entrance to Boston Harbor, and commands the anchorage of Nantasket Roads.

Operations at this work resulted in the entire completion, as at present planned, of the ravelin battery; in the completion, as far as at present possible, of the batteries of bastion A of the enciente, and the commencement of the modifications of bastion B, in which one large magazine-arch has been completed.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $50,000

Battery at Long Island Head, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—This work occupies an important position in the outer line of defense to Boston Harbor, and its guns bear upon all the channels of entrance thereto.

Active operations were in progress during but five months of the year, and in that time four 15-inch front-pintle gun-platforms, together with their breast-height walls, were entirely completed, ready for their armament. Eleven of the 27 platforms of this battery are therefore now ready for their armament.

The parados arch and its entrances were completed in rear of the fourth pair of guns, and the earth-cover of the arches and the sodding of the slopes were essentially completed from its east end westward, to include the magazine for the fourth pair of guns.

No active operations are expected during the present fiscal year.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $50,000

Fort Winthrop, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—This is one of the works forming the inner line of defense to Boston Harbor and the n[illegible]-yard at Charlestown.

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Active operations at this work have been extremely limited, and have been confined to the completion of the east and south batteries, (comprising 43 15-inch gun-platforms,) excepting about one-half of the new sand-parapet of south battery.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $50,000

Fort Independence, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—This is one of the works forming the inner line of defense for the harbor of Boston.

Operations were confined to the five months ending December 1, 1875, and resulted in the completion of the present proposed modifications of the barbette battery of the enciente; in the essential completion of the masonry of the east exterior battery, so that its five platforms are now ready for their armament, and in the building of about one-half of the new parapet of this battery.

An iron ladder and balcony were built on the parade-wall of front I, to serve as a direct communication from the parade to the batteries of this front.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $30, 00

Fort at Clark's Point, New Bedford Harbor, Massachusetts, in charge of Maj. G. K. Warren, Corps of Engineers.—The guns of this work command the entrance to the harbor of New Bedford.

Nothing has been done during the past fiscal year except taking care of the property, and scraping and painting the iron-work of the fort.

Plans for the heavy-gun batteries are ready, and work can be begun as soon as money is appropriated.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $30,000

Fort Adams, Newport Harbor, Rhode Island, in charge of Maj. G. K. Warren, Corps of Engineers.—This large and important work defends the harbor and city of Newport, and commands the principal passage to Narraganset Bay, one of the best roadsteads on the coast.

During the past year two granite platforms, with traverse circles and pintles, were procured, and four platforms set, (except the traverse circles and pintles,) together with breast-height wall and parapet which was completed in their front. Considerable work was expended in grading in rear of the new battery, the surplus earth being used in constructing the traverses. A masonry-well and man-hole shaft, with suitable coverings, was built to the main outlet of the drains on the west front, which pass under the parapet. A fence was built around the new battery to protect from intrusion. A shed was also constructed to protect from the weather the carts and other wheeled vehicles.

During the present season no work has been done immediately on the new battery, all the money available being required to put it in proper condition to suspend operations.

Besides the new battery, many repairs are necessary to the main work and permanent wharf.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $45,000

Defenses of Dutch Island, western entrance to Narraganset Bay, Rhode Island, in charge of Maj. G. K. Warren, Corps of Engineers.—These defenses lie in and command the western passage to Narraganset Bay.

During the past year platforms for four guns have been laid, breast-height wall completed, and parapet partly raised in front of two, and

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banquette completed in their rear; and a beginning made on "bonnets" of two adjoining traverses; foundation and forms for breast-height wall placed for the other two platforms; traverse circles and pintles purchased and on hand for six guns; and material, except granite, on hand to complete two more platforms.

During the present season no work has been done immediately on the new battery, the money available being required to make necessary repairs and put the place in proper condition to suspend operations.

The operations during the present fiscal year will consist in care of public property.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $37,500

Fort Trumbull, New London Harbor, Connecticut, in charge of Maj. J. W. Barlow, Corps of Engineers.—This work, upon the west bank of the Thames River, with Battery Griswold on the east bank, forms the defense of the harbor of New London.

During the past fiscal year the north exterior battery has been completed, except setting the platform irons and placing the magazine lamps. Work has ceased from the exhaustion of the appropriation.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $40,000

Fort Griswold, New London Harbor, Connecticut, in charge of Maj. J. W. Barlow, Corps of Engineers.—The only work done during the past year was making survey of the boundaries of the United States lands.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Hale, New Haven Harbor, Connecticut, in charge of Maj. J. W. Barlow, Corps of Engineers.—This work commands the channel of entrance to New Haven Harbor.

No work has been done during the past fiscal year. The position of the opening of the beach has shifted westward. During the winter the sea-wall, near the southwest salient, suffered some injury. The total cost of repairs is estimated at $1,500.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Schuyler, East River, New York, in charge of Maj. H. L. Abbot, Corps of Engineers.—This is an important work for the defense of the entrance to the harbor of New York City through the East River.

During the past fiscal year, in the main work, north face, 90 cubic yards of sand have been placed on parapet, and 200 cubic feet of old concrete have been removed from the tereplein of northeast angle.

In the north bastion, brick revetment to preserve the foot of the exterior has been built, and the bastion has been covered with earth and sodded.

In the northeast face, magazine No. 4 has been completed; brick entrances have been built, steps and lintels, stone jambs, arch-stones, and stone for retaining wall have been cut and set; brick revetment for the preservation of foot of interior slope has been built on retaining wall; the outside surface has been covered with lime-mortar and asphaltum, sand and earth, and the slopes have been sodded.

In the southeast face, brick revetment for the preservation of the foot of exterior slope has been built on coping of scarp-wall, and the joints of the coping have been pointed with asphaltum. Lime-mortar and asphaltum have been applied to large arch between piers L and M. The parade-wall has been backed with concrete as far as the crown of

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the arch between piers L and M; asphaltum has been applied to the arches between magazines 4 and 5, and the same have been covered with sand. All the concrete work of magazine No. 5 has been completed, together with the brick entrances and retaining wall; the magazine has been covered with earth and sand, and sodded; 78 linear feet of parapet have been built to full height and thickness, and the same amount to an average thickness of 10 feet. Exterior slope has been sodded, except about 12 feet near the south bastion; mortar and rubbish have been removed to make room for the parapet; 329 cubic yards of sand for covering magazine No. 6, and 150 cubic yards of sand for building parapet have been transported from the beach, and placed conveniently.

The south bastion of the main work has been cut down to the proper level, and the coping has been set, and partly backed with concrete. Three courses of stone have been removed from tower.

In the south face, 16 linear feet of old stone parapet and one platform have been removed.

The torpedo-gallery has been completed, and a trench for torpedo-cable has been built 61 linear feet beyond the sea-wall, and covered with sand.

In the ten-gun battery 666 pieces of ashlar, removed from the old parade wall of main work, have been transported to the battery for the purpose of constructing breast-height walls. A rubble-stone wall 149 feet long has been built at the west end of the battery to prevent the washing away of the bank.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $50,000

The main work is nearly remodeled to receive the platforms, breast-height walls and armament; but is in such a condition that considerable time is needful before it would be possible to actually mount the latter.

The vast importance of the channel, and the fact that the removal of the obstructions at Hell Gate is rapidly progressing, renders it highly important that work should be resumed at the earliest possible moment.

Fort at Willet's Point, eastern entrance to New York Harbor, in charge of Maj. H. L. Abbot, Corps of Engineers.—This work unites with Fort Schuyler, in the defense of the entrance to the harbor of New York City, through the East River.

During the past fiscal year, the torpedo casemate has been prepared according to plan of Board of Engineers.

In the mortar battery about 60 square yards of the sodding of interior slope, which was washed down by heavy rain-storms, have been repaired.

Two new storage casemates, 15 feet wide by 85 feet long in rear of the easterly end of middle battery, for which foundations were laid during the last fiscal year, have been finished; their arches, side and rear walls have been covered with lime-mortar and mastic, porous drain-pipes have been laid in the valleys between the arches and covered with gravel; 41½ linear feet of blue-stone coping have been set, and about 1 foot of earth has been placed on top of arches, the latter work partly by engineer troops; two casemates have been closed by wooden bulk-heads and doors, and low brick bulk-heads have been built at the entrances to two casemates now containing torpedo cable. A large silt basin has been constructed at the upper entrance of underground passage-way to the stone fort, for the purpose of draining the whole area in rear of casemates; and a tank of concrete has been built in rear of casemate No. 8, for the purpose of testing torpedo-cable.

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One hundred and eighty-four linear feet of sea-wall in front of Little Bay battery, toward the wharf, have been completed, making a thorough finish of the whole wall between northwest curtain of stone fort and fort wharf; a considerable amount of riprapping has been done, partly by engineer troops.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $80,000

A large appropriation is urgently needed, not only on account of the importance of the channel to be protected, but also because the condition of the work is such that rapid and costly deterioration results from leaving it exposed in its present unfinished condition.

Fort Columbus, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—During the past year repairs were made to the drawbridge and approach, and the engineer wharf was replanked. This work should be provided with sewers to connect with the latrines, which, by means of a force-pump, could be flushed with salt water, or, better still, should well-sinking prove to be a success, with fresh water.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $5,500

New barbette battery at Fort Columbus, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—No work was done here during the past fiscal year, and none contemplated during the present year.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Castle Williams, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—No work was done here during the last fiscal year. The casemates of this old work are used by the general recruiting-service as quarters, &c. The mastic pavement of the terreplein is in very bad order, permitting extensive leaks into the quarters. This pavement cannot stand exposure to the sun and frost, and requires continual repairs and renewal. A new roof is needed, for which an appropriation is asked.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $8,000

South Battery, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—No work was done here during the past fiscal year, and none contemplated during the present.

Fort Wood, Bedloe's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—This work, together with those upon Governor's Island, is designed to close the entrance to the East and Hudson Rivers, and to cover New York, part of Brooklyn, and Jersey City from bombardment.

No appropriation was made for this work for the year ending June 30, 1876. The small balance on hand at the beginning of the year was used on the exterior water-battery in grading terreplein and filling in parapet. Permanent doors were hung to magazines Nos. 3 and 4.

The main drain or sewer in parade of the fort was depressed its entire length in order to give sufficient descent to carry off the sewage.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Hamilton, and additional batteries, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—These works are situated at The Narrows of New York Harbor, upon the Long Island side.

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During the year, in Battery 1, the platforms and breast-height wall were completed. The parapet and end of traverses have been raised to the required height, and rear slopes of parapet sodded.

In the 15-inch gun battery no work was done except slight repairs to the slopes.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $10,000

Mortar Battery at Fort Hamilton, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers.—During the year repairs have been made to the silt basins, surface-drain cut to carry off water from around platform No. 1, terreplein graded, and soil spread on slopes.

Fort Wadsworth, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This fort is situated on the Staten Island side of The Narrows of New York Harbor, and is a large, casemated work. The operations during the last fiscal year have been mostly restricted to the preparation of the necessary appliances for the defense of the channel by torpedoes. This has been completed, with the exception of a small amount of concrete-work, which can be put in in a few days.

The store-room roofs, over the two principal magazines, and the roof of the guard-house, have been repaired and painted.

There has been no change in the armament of the work. The ditch requires cleaning out; some painting, lacquering, and pointing are necessary; and shot-beds are needed on the parade of the work.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort on site of Fort Tompkins, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work crowns the hill in rear of the open batteries and other works on Staten Island defending the entrance through The Narrows to New York Harbor, acts as a keep for these works, and, when completed, will throw a heavy fire from a high elevation upon vessels attempting to pass before it.

During the past fiscal year a covered reservoir, for furnishing the garrison with fresh water, was constructed in the glacis, near the angle of the counterscarp of the south and southwest faces. It has a capacity of 50,000 gallons, supplied from a spring which flows into the ditch of Fort Wadsworth, near the southwest angle. The spring yields an ample supply of excellent water, which is collected in a supply-basin formed by the erection of two concrete walls across the ditch of the work, inclosing an area of 3,150 superficial feet. The water is forced from the supply-basin into the reservoir, through a 4-inch cast-iron pipe, by means of a steam force-pump located in one of the lower rooms of the guard-house of Fort Wadsworth. From the reservoir two 6-inch cast-iron pipes conduct the water away; one of them to the latrine in the south ditch of Fort Tompkins, the other to the parade of the work, with branch pipes into a casemate used as a bath and wash rooms. This pipe has been continued by the Quartermaster's Department to the officers' quarters and hospital, situated on a level upward of 50 feet below the floor of the reservoir.

The new soldiers' latrine, at the east end of the south ditch, is 14 feet by 24 feet inside; is built of brick, with 12-inch walls above the floor, over a sink 7 feet wide and 8 feet deep, in which water constantly stands at the depth of 2 feet, with appliances for flushing it whenever necessary. The floor and risers of the seats are of cut blue-stone flagging, with yellow-pine coping for the seats.

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The other operations have consisted in hanging the sally-port doors, pointing the cut-granite masonry in the breast-height walls, barbette traverse magazines, and a portion of the the parade piers along the channel front, in repairing and preserving the slopes, and straightening the sewer leading from new latrine to the river at its point of junction with the old latrine.

The expenditures not contemplated in the original projects for the year have amounted to about $10,000. The fort is in readiness to receive its armament of channel-bearing guns.

No operations can be carried on during the present fiscal year for want of funds. The large slope between the fort and the south end of the north cliff battery is in a very bad condition, and provision ought to be made for grading it into terraces and completing it.

No appropriation was made for the fiscal year ending June 30, 1877.

Appropriation asked for the next fiscal year to continue the work, and the north cliff and south cliff batteries $50,000

Glacis Gun Battery, (north of fort, on site of Fort Tompkins,) Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This battery has been in readiness to receive its armament for the last three years. Some little work yet remains to be done to the magazine doors and lamp-closets. No work was done during the last fiscal year except to cut the grass from the slopes and repair minor damages to the same.

No appropriation asked for next fiscal year.

Glacis Mortar Battery, (south of fort, on site of Fort Tompkins,) Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This battery and its armament are ready for service. During the past fiscal year portions of the slopes damaged by heavy rains have been repaired and resodded. A little work yet remains to be done upon the lamp closets, and the principal magazine requires to be furred off.

No appropriation asked for next fiscal year.

Battery Hudson, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work, together with those on the north and south cliffs, forms a system of open barbette batteries lying exterior to Forts Tompkins and Wadsworth, and bringing a powerful fire to bear upon the channel up to and through The Narrows.

The operations on the east face of the battery consisted in constructing the granite masonry of the permanent breast-height wall and low traverse platforms Nos. 2 and 3, built with the additional height required for the new ordnance carriage. The platforms are completed, with the exception of the iron traverse rails and a portion of the earthen parapet. Granite was also prepared for three permanent platforms, Nos. 7, 8, and 9, intended to be constructed on the site now occupied by the six 300-pounder Parrot rifles; but these rifles have not yet been removed, as was contemplated at the beginning of the fiscal year, it being thought best not to reduce the existing armament.

In the extension of the battery, a permanent breast-height, wall with bomb-proof shelter, and retaining wall at the west end of the battery, have been constructed. The five wooden platforms have had the rear traverse rails cut off, and, in connection with permanent outer traverse stones, have been relaid for the new ordnance carriage. These platforms are complete except the outer traverse rails, which will be put down with the balance on hand; all the finished masonry in the battery has been pointed, and some extensive damages to the earth-slopes re-

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paired. No platforms have been made ready for the guns since the last annual report, but two will be completed during the present month.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year to continue the work..... $31,000

South Mortar Battery, (in rear of Battery Hudson extension,) Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—The work necessary for the completion of this battery consists in constructing and laying eight timber mortar platforms upon concrete foundations, now in place, in fitting up the inner magazine doors and two lamp closets. No platforms are finished.

No appropriation was made for the fiscal year ending June 30, 1877.

North Cliff Battery, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—No operations were carried on during the fiscal year except repairing a portion of the slopes, and cutting grass.

This battery is ready for four guns, in addition to those already mounted.

No separate appropriation is asked for the next fiscal year.

South Cliff Battery, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—The project submitted at the beginning of the fiscal year was modified in order to construct the supply basin, reservoir, and latrine, and repair damages to slopes, referred to in the report on Fort Tompkins.

In accordance with the plans for the modification of the battery, the new traverse magazine, with covered passage, near the north end of the battery, has been finished, except a portion of the earthwork and the doors. The front wall of the covered passage opposite the north principal magazine has been carried to the springing-line of the arch, and the granite skewback laid. The covered passage to be added to the old traverse magazine, north of the above-named principal magazine has had the rear wall of the passage built to the skewback and the skewback laid. The center pintle platform, No. 17, was removed and sent to Fort Sumter, and the front pintle platforms, Nos. 4, 5, 11, and 12, (old numbers,) were removed in the execution of approved modifications.

Excavations have been made in two places through the parapet and 8-inch drain-pipe laid to near high-water mark, to afford additional drainage for the battery.

Eight guns are in position in this battery, and the platforms are ready for all the others.

No separate appropriation asked for next fiscal year.

Fort at Sandy Hook, New Jersey, in charge of Lieut. Col. John Newton, Corps of Engineers.—One of the great objects of this work is to prevent the occupation of the lower bay as an anchorage by an enemy's fleets.

No operations have been conducted during the year except occasional repairs to the jetties and taking down and storing away derricks. The southern boundary-line has been laid out and marked by granite blocks.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Mifflin, Delaware River, Pennsylvania, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—This fort constitutes one of the inner line of works for the defense of Philadelphia and the naval establishment at League Island.

During the past fiscal year a torpedo casemate of concrete masonry, with sodded covering traverse, has been completed, excepting a portion

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of the gallery extending beyond the scarp-wall. The traverse rails of gun-platforms 30, 31, 32, 33, 34 and 35, main work, were laid. In the exterior battery, nine wooden gun-platforms have been laid; the brick breast-height wall, with concrete backing, in front of gun-platforms 43, 44, 45, 46, 47 and 48 has been completed; magazine 44–45 finished, except sand traverse, and the concrete masonry of magazine 46–47 completed with mastic covering. All this concrete masonry is protected by a covering of sand, the terreplein and parapet of gun-platforms 43 and 44 have been partly graded ready for seeding, and sods have been placed on the steep slopes along the edge of the breast-height wall. About 700 cubic yards of sand have been received and embanked in the battery. In addition to the above, and the necessary grading of the slopes, the steep profile slope of the down-river branch was sodded; repairs have been made to the sodded slopes of main work and demilune; repairs to the dike at several places on Delaware front made, and an accumulation of mud in the moat has been removed.

No appropriation having been made for the present fiscal year, the work will be placed in the care of a fort-keeper and watchman.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $75,000

During the next fiscal year it is proposed, if funds are provided, to complete the exterior battery, the modification of south 15-inch-gun battery, of the demilune, the battery on the south face of the main work for two 15-inch guns, and construct the storage magazine of the demilune.

Mortar Battery at Fort Mifflin, Delaware River, Pennsylvania, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—No work has been done at this battery during the past year for the want of funds, and none is proposed for the present fiscal year, for the same reason.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Site for the defenses at Red Bank, New Jersey, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—During the past year necessary small repairs have been made to the dikes, buildings, and fences, and general care and supervision have been maintained over the property. The funds for these purposes were allotted from the appropriation for contingencies of fortifications.

No appropriation has yet been made for a battery on this site.
No appropriation asked for next fiscal year.

Fort Delaware, Delaware River, Delaware, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—This work, situated on the Pea-Patch Island, forms one of the chain of works constituting the outer line of defense for the Delaware River.

The small amount available during the past fiscal year has been applied to such repairs as were most necessary, and to the preservation of public property.

The timber foundation of upper eastern wharf has been protected from the ice by iron-plating, and injury to the stone superstructure has been repaired, and the top of the wharf has been finished for 10 feet back from the head. Some repairs have been made to the southern wharf, and the bridge leading to it has been rebuilt. A portion of the flagging of the parade-walk has been relaid. Slight repairs have been made to temporary buildings and fences, and the sodded slopes and grounds have been kept in good condition.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $40,000

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Battery at Finn's Point, Delaware River, New Jersey, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—This is a powerful earthen barbette-battery, and forms the left of the outer line of defenses across the mouth of the Delaware River.

During the past year two stone gun-platforms have been finished, and the breast-height wall in front of them nearly built; the stone for two additional platforms has been nearly all prepared for setting, and the concrete foundation for them has been laid.

One service-magazine has been built; the one built last year has been fitted up, and its covering traverse has been embanked and sodded.

The embankment of battery and parapet has been continued, much of the material having been taken from the beach in front.

The sea-wall south of the wharf to the boundary-line has been entirely rebuilt on a foundation of light piling; about 80 linear feet of the wall in front of mortar-battery has also been repaired.

The fence partially inclosing the Government grounds has been extended 1,970 linear feet.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $50,000

Mortar-Battery at Finn's Point, Delaware River, New Jersey, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—No operations were carried on at this work during the past year for want of funds, and none are contemplated for the present year. Its condition remains the same as at the date of the last annual report.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort opposite Fort Delaware, Delaware shore, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—A strong earthen barbette battery, forming the right of the outer line of defenses for the Delaware River.

During the past year the magazine and shelter room at intersection of gun and mortar batteries, with their covering traverse, have been completed; the magazine next in order to the left has been built, and its traverse partly embanked; the connecting breast-height wall has been nearly finished; the stone for two gun-platforms has been prepared, with the exception of a few pieces, and the concrete foundation for them has been laid; a torpedo-casemate has been constructed and covered with earth, and the cable-gallery leading from it has been partially constructed; the ramp from mortar-battery has been formed, and the slopes in rear, together with the rear slope of gun-battery for 300 feet, have been embanked and sodded. The embankment of the battery has been continued.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $50,000

During the next fiscal year it is proposed, if funds are provided, to complete the unfinished breast-height wall, two gun-platforms, and the magazine traverse; to construct additional gun-platforms of stone, with the breast-height walls in front, and magazines, with their covering traverses; to complete the torpedo-gallery, and to continue the embankment of the battery.

Mortar-Battery near Delaware City, Del., in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—Nothing has been done on this work during the year, and its condition remains the same as at the date of the last annual report.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

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Fort McHenry, Baltimore Harbor, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers.—This fort forms part of the inner line of defense for Baltimore and its dependent interests, and commands with its fire the interior waters of the harbor and the channel of approach thereto, in which 24 feet can be found at mean low-water.

This site at the entrance of the inner harbor of Baltimore, though it has lost much of its importance owing to the growth of the city toward it, should still be occupied by a battery of heavy guns near the water-front, mounted behind a sand parapet of the latest and most improved model, and provided with bomb-proof cover for ammunition and gunners. Such a battery would be of inestimable value in the defense of the city against an enemy afloat who by force or stratagem had passed the outer lines of defense, and it might also play an important part in the defense against any force on land co-operating in that quarter with a fleet. Such a battery is being constructed. No dependence can be placed on the old historic fort, McHenry, which did its part so well in repelling the attack made in the war of 1812.

The condition in which this battery stood June 30, 1874, is given in the last annual report, coupled with the statement that nothing could be done for want of funds, except in the way of care and preservation, during the year ending June 30, 1875.

An appropriation of $20,000 was made February 10, 1875. Work was resumed July 1, 1875, suspended late in November, 1875, and resumed in May, 1876. At the end of June, 1876, the appropriation was nearly exhausted. The work of the year embraces the extension of the sand parapet of front 4 to the salient 3–4, and building 10 feet of the parapet of front 3, and the sod revetment. The sand covering has been placed on the three magazines previously built, and doors have been made for them, which are in store at Fort Carroll for better preservation. The terreplein has been partly regraded, and a layer of soil put upon the slope in rear of the battery, to secure a growth of grass. Some repairs of small extent were made in the spring of 1876 to the slopes of the magazines and parapet of the old water battery, which is kept up until the completion of the new one.

It is not deemed expedient to put down gun-platforms until the terreplein embankment becomes more consolidated, the subsoil being somewhat unstable.

The sum of $50,000 is asked for the next fiscal year, which would complete nearly the whole of the parapet and terreplein, with magazines, but no gun-platform.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $50,000

Fort Carroll, Baltimore Harbor, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers.—This fort is situated upon an exterior line of defense for the harbor of Baltimore. It is a casemated work, but nothing has been done in the past year in carrying out the project for its completion, which contemplated the provision for three tiers of guns in casemates and one in barbette. This delay is due to the fact that the best method of arranging such defenses, consistent with a due regard to economy, has not yet been determined.

During the past year nothing has been done but what was necessary for preservation and care of property. This work consisted of repairs to fences, sheds and roofs over masonry, which were damaged by the weather, especially very high winds. Electrical conductors were placed over magazines in three of the salients. There has been no change in the armaments since last annual report. The details of the arrangements

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proposed for the use of torpedoes from this fort have been determined upon, and drawings, &c., have been prepared, but their construction has been deferred for want of funds.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Obstructions of the Potomac, in charge of Maj. William P. Craighill, Corps of Engineers.—The material pertaining to these floating obstructions has continued in store at Fort Foote, in charge of a watchman. The timber, of which the floats are composed, has decayed very much.

Fort Foote, Potomac River, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers.—This work is on the inner line of defense of the channel of approach by water to Alexandria, Washington, and Georgetown. The site is high, commanding, and unusually favorable.

There having been no specific appropriation for Fort Foote, the work done has been limited to some repairs of moderate extent, required for the safety and use of the wharf. These repairs were made in June, 1876. The crib-work on the down-stream side of the causeway-approach to the wharf has been replaced. The abutment of the wharf, also of crib, was extended down stream 16 feet, or even with the projecting portion of the wharf. This was done with a view to future repairs, the extension being expected to serve as part of the abutment of the new portion. Total length of crib-work, 125 feet. A portion of the head of the wharf, 12 feet in length, has been cut down to facilitate landing from boats.

Attention is again urgently invited to the fact that the unfinished condition of this fort must render it liable to certain injury and deterioration; and to properly care for the work already done, the modification of the main fort should be completed as early as possible. Appropriation for this purpose is very important. All the work now proposed at this place and at Fort Washington is in the way of preparation for mounting the heaviest guns known to our service behind sand parapets of the latest and best models.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $50,000

Fort Washington, Potomac River, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers.—This fort occupies a very important position on the outer line of defense of the cities of Alexandria, Washington, and Georgetown, and their dependent interests. The site is an excellent one, but the line requires strengthening by the introduction of guns of the heaviest caliber, for which the old fort was not suited.

During the past fiscal year, for want of funds, nothing was attempted but to make some repairs of limited extent to the wharf, and the lightning-rods of the magazines, &c. In June, 1876, the replacing of 80 feet of crib-work was commenced on the south side of the bulkhead of the wharf. The earth backing has been removed, and the timbers taken out as far down as the low-water line, under which level the crib-work is in good condition. Putting on the new timber has commenced. Lightning-rods over the magazines inside the fort, and at commanding-officers' quarters outside, have been repaired, and insulators have been replaced on all the rods where needed.

The maps are completed as far as seem necessary for preparing a revised project of defense, which is expected to be shortly ready.

Attention is again pressingly asked to the need of the appropriation asked for this fort. The portion of the work begun should be finished.

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It is daily suffering serious injury and deterioration, owing to its incomplete state.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $38,000

Fort Monroe, Old Point Comfort, Virginia, temporarily in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This extensive work occupies an important position, covering the approach to Hampton Roads, the navy-yard at Portsmouth, and the James River.

During the past fiscal year work has been confined almost entirely to the advanced redoubt. In this the platforms and breast-height walls for guns Nos. 1, 2, 3, and 4 have been completed, except pintle and traverse circles, and the foundation for the breast-height wall and platform for guns Nos. 5 and 6 have been completed and the pintle-blocks and prop-stones set. The two service magazines have been plastered, and the magazine traverse between guns 3 and 4 raised and sodded from reference (6′) to reference (26′,) the level of the interior crest. The terreplein and slopes in gun-space next the main work have been completed and sodded, and 125 linear feet of exterior slope sodded from reference (60′) to reference (21′,) or (2′ 6″,) below the exterior crest. The roadway of the main postern of the fort has also been repaved. Three platforms for heavy guns and fifteen for lighter ones are now in readiness, but not occupied; four others for heavy guns in the redoubt will also be in readiness when supplied with pintles and traverse circles.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriations asked for next fiscal year..... $75,000

Artesian well at Fort Monroe, Virginia, temporarily in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—No work was done during the last fiscal year, and none is contemplated during the present fiscal year for want of funds. The inadequate and uncertain supply of water at Fort Monroe is an evil which, it is conceded on all sides, may at any time arise to serious magnitude. The present depth of the well is about 900 feet. It is recommended that provision be made to increase this depth to 1,200, or even to 1,500, feet before abandoning the project of obtaining a water-supply by this method.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Wool, Hampton Roads, Virginia, temporarily in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This casemated fortification unites with Fort Monroe in closing the passage to Hampton Roads, crossing its fire with the guns of that fort.

Until approved projects for its completion are devised, no further work is contemplated than is necessary to preserve it from injury. Fifty-two iron-throated casemates of the first tier are ready for guns, and in an emergency several 15-inch guns could be advantageously and promptly mounted in barbette.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Macon, Beaufort Harbor, North Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—Situated at the mouth of the harbor and defending the principal entrance thereto.

The subject of the modification of this work is still under consideration.

During the last fiscal year monthly measurements have been made of the position of the shore-line in the vicinity of the wharf. These observations show no appreciable change in the beach.

No appropriation is asked for this work.

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Fort Caswell, mouth of Cape Fear River, North Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—The subject of the modification of this work is still under consideration.

Its location is advantageous for the protection of one of the entrances to Cape Fear River, and therefore one of the approaches to the city of Wilmington.

There is neither armament nor garrison, nor quarters for a garrison, at the place.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Moultrie, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—Situated on Sullivan Island and defends the principal entrance to the harbor of Charleston.

During the past fiscal year work has been done mainly in the northwest bastion. The old storage magazine has been remodeled and a service magazine, permanent platform and breast-height wall for gun No. 12, have been completed. The remainder of the bomb-proof along the gorge face, 75 feet in length, has been raised from reference (0′) to reference (5′ 6″.) The postern front has been completed and the foundations and walls of the galleries leading to it raised from reference (0′) to reference (6′.) Eight platforms, one permanent and seven timber, are now in readiness for, but not occupied by, heavy guns. Four mortars are mounted in rear of the fort. The laying of two timber platforms now on hand in place of those occupied by light guns will complete the preparation for arming this work.

Estimated cost of completing the work $85,000. This estimate includes the cover-face and the building of eleven permanent platforms in place of the eleven timber platforms which are now in position in the work, and which were not included in the estimate made last year.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $50 000

Fort Sumter, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work is located on a shoal near the mouth of the harbor, and its guns command the principal channel of entrance thereto.

During the past fiscal year the storage-magazine, breast-height walls, and permanent platforms for guns Nos. 1, 2, and 3, front pintle for Nos. 2 and 3, and center pintle for No. 1, have been completed. The entire scarp-wall of northwest and gorge fronts has been coped with concrete, except the opening left as a passage-way into the fort. Four magazine-doors have been framed and seven riveted and hung, (one in each service magazine in the fort.)

The eleven casemates on the north and northeast fronts have been uncovered, the backs of the arches asphalted, the sand filling returned, and the parapet completed. The lintel and pediment for parade end of sally-port gallery, together with the coping of the wing-walls and the stone steps leading to man-holes of cisterns adjoining the sally-port, have been placed in position. The parapet on northwest front has been raised from reference (18′) to reference, (22′,) and that portion of the parados in rear of this front north of barbette-service magazine from reference (14′) to reference, (28′.)

Four platforms, one timber and three permanent, for heavy guns, are ready, but not occupied. The replacing of two platforms now occupied by light guns, by heavy timber platforms, which are on hand, would make the work ready for its armament. The eleven casemates on north-

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east front are armed. The eight casemates on northwest front are now ready for their guns, except traverse circles.

Estimated cost of completing the work, $65,000. This estimate includes the building of seven permanent platforms in the place of the seven timber platforms which are now in position in the work and which were not included in the estimate made last year.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $40,000

Fort Johnson, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This fort, situated on James Island, is one of the works in the system of defense of Charleston Harbor.

No operations were carried on at this work during the past fiscal year. The approved project for reconstructing this old work contemplates making of it a battery for eight pieces of heavy ordnance, four mortars and four guns. Its commencement and completion during the next fiscal year is recommended.

Four 13-inch mortar platforms are on hand, ready to be laid.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Castle Pinckney, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work, situated on an island near the city of Charleston, is one of the works in the system of defense of the harbor.

No operations were carried on at this work during the past fiscal year. An appropriation is required to adapt it to the reception of 10-inch smooth-bore guns or corresponding rifles, to be mounted in barbette.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Jackson, Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work forms the inner line of defense for the city of Savannah.

During the past fiscal year a service traverse-magazine has been built between guns 3 and 4 of the barbette battery. Five guns are in position, but they are not of the calibers contemplated in the approved project, and cannot be efficiently served without a completion of the work.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $8,000

Fort Pulaski, mouth of Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This is the principal work for the defense of Savannah on the outer line of the system.

During the past fiscal year the entire demilune was completed in accordance with the approved plan, except the retaining wall in demilune sally-port and the filling immediately behind it. This wall was completed during the fiscal year ending June 30, 1875, but was not found sufficiently strong to bear the thrust of the filling behind it, owing to the unstable nature of the material in which the piles were driven. It was finally taken down, the piling strengthened, and the wall rebuilt, which is now complete except coping.

The modification of the main work in accordance with the approved designs was commenced. The new piers on the north front, numbered from the northwest bastion, have been raised to the following heights: Those opposite Nos. 2, 3, and 4, to reference (11′ 6″;) opposite Nos. 5 and 6, to reference (7′;) and opposite No. 7, to reference (2′.) Estimated cost of completing the work, $235,000.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $75,000

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New fort on Tybee Island, mouth of Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—Plans for the defensive works to be constructed on the north point of Tybee Island have been completed, and it is proposed to commence their construction whenever funds are available.

No appropriation for the work has yet been made.
No appropriation asked for next fiscal year.

Fort Clinch, Amelia Island, Florida, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work defends the entrance into Cumberland Sound, and is in an unfinished condition.

No operations were carried on at this work during the past fiscal year, its modification being still under consideration.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Marion, Saint Augustine, Florida, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work defends the harbor and city of Saint Augustine.

During the last fiscal year a temporary roof of scantling and boards, covered with felt, was constructed over the terreplein of the north front and a privy was built, all for the accommodation of the Indian prisoners or hostages confined in the work. One casemate on the south front was put in order for a guard-room, and a break in the retaining-wall at the foot of the glacis, on the north side, was repaired. These alterations and repairs were made from the appropriation for contingencies of fortifications, at a cost of $1,394.03.

No appropriation is asked for this work.

Fort Taylor and batteries, Key West, Florida, in charge of Maj. Jared A. Smith, Corps of Engineers.—This work is for the defense of the important harbor of Key West.

During the past fiscal year, all the bricks and movable materials have been transferred from the towers to the batteries and warehouses. One mile of the railroad has been removed and the materials stored. The hurricane of 1875 occasioned such damages to the southwest portion of cover-face and other parts as to necessitate the expenditure of remaining funds in reconstructions and repairs. A breach 150 feet in length, about 600 cubic yards, was made in the sea-wall, drains were filled with dirt, and fences and water-conductors were broken down. These have all been put in good order, and other parts of sea-wall have been repaired. This has included the laying of 603 cubic yards of concrete, 228 cubic yards of granite, and the wheeling and embanking of 1,469 cubic yards of sand and small stone. Sixteen hundred and forty-four linear feet of water-gutters have been repaired and painted, and 1,596 linear feet of board-fence built for protection of south battery. The concrete portions of wall below water were laid in bags, without being previously wet, each layer being well rammed. This entire repair has been done with such implements as could be improvised, and with the laborers most of the time to their waists, or deeper, in water. No work has been done on the sand-batteries. The designs for batteries have been considerably modified, so that the guns may be protected singly instead of in pairs. This reduces the emplacements in south battery to 14, and in north battery to 8.

The heavy guns now in these batteries and main work are on wooden platforms, which are becoming unserviceable, and should be permanently rebuilt. The long bridge, forming the only communication with the main

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work, must soon fall unless rebuilt, and considerable other work is required, for which a large appropriation is greatly needed.

At the martello towers, to prevent intrusion and depredations, the entrances and embrasures have been closed with strong shutters, and watchmen have been employed as fort-keepers. The movable property requiring care has been placed in warehouses of Fort Taylor.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year.....$75,000

Fort Jefferson, Garden Key, Tortugas, Florida, in charge of Maj. Jared A. Smith, Corps of Engineers.—The guns of this work perfectly command the admirable harbor lying in the heart of this group of keys.

No appropriation being available for construction, the expenditure has been confined to care of public property and buildings.

All the property has been moved, completely stored, and, as far as possible, put in order. Windows of barracks and quarters have been closed with temporary wooden shutters.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year.....$25,000

Fort Pickens, Pensacola Harbor, Florida, in charge of Capt. A. N. Damrell, Corps of Engineers.—This work, with Fort Barrancas and the proposed new batteries near the site of Fort McRee, constitute the defenses to the town and harbor of Pensacola and to the navy-yard at Warrington.

During the past fiscal year, quarters, store-houses, blacksmith-shop, and wharf were repaired. A new stable, mess-hall, and kitchen were built. A railroad-track was laid. Four cars were built. Two derricks were made and raised. The modifications of bastion C were completed according to the approved plan of the Board of Engineers for Fortifications, with the exception of the stone center-pintle platform, and work was commenced on the modifications of bastion D.

During the present working season it is expected to finish bastion D.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $75,000

Fort Barrancas and redoubt, Pensacola Harbor, Florida, in charge of Capt. A. N. Damrell, Corps of Engineers.—No changes have been made in this work during the last fiscal year, operations having been restricted to those necessary for the proper care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort McRee, Pensacola Harbor, Florida, in charge of Capt. A. N. Damrell, Corps of Engineers.—The condition of this work is about the same as at the date of the last annual report. No work was done during the past fiscal year, and none contemplated for the present.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $50,000

Fort Morgan, eastern entrance to Mobile Bay, Alabama, in charge of Capt. A. N. Damrell, Corps of Engineers.—This work, with Fort Gaines on the western side of the entrance, forms the outer line of defense to the harbor and city of Mobile.

During the past fiscal year, quarters, kitchen, mess-hall, stables, and railroad-track to the wharf were repaired. Two thousand six hundred and eighty-seven feet of new railroad-track and four cars were built. Parados, parapet, breast-height wall, and foundation for the gun-platform for gun-position No. 1, service-magazine for the battery, breast-

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height wall, foundation for gun-platform, and portion of the parapet for gun-position No. 2, were completed.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $75,000

Fort Gaines, Dauphin Island, Mobile Bay, Alabama, in charge of Capt. A. N. Damrell, Corps of Engineers.—Operations during the year were confined to the care of public property. The condition of this work remains the same as last year.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort on Ship Island, coast of Mississippi, in charge of Capt. A. N. Damrell, Corps of Engineers.—This work affords shelter to light-draught vessels moving in Mississippi Sound.

During the last fiscal year the stone flagging in this fort (272 square yards) has been completed, the store-house and fort-keeper's quarters have been put in good repair, and all iron-work and other property exposed to the weather has been properly stored. This work was done under the allotment from the appropriation for contingencies of fortifications.

No preparations have been made or are intended for any change in the armament.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Pike, Rigolets Pass, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work commands the passage by vessels drawing 7 feet or less, through the Rigolets, into Lake Pontchartrain, and to the wharves on the lake front of New Orleans. Projects for its modification, in accordance with the approved system, were approved in 1870, and detailed estimates of the cost of the proposed modifications made.

During the past fiscal year operations have been confined to necessary repairs for the preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Macomb, Chef Menteur Pass, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work commands the passage by vessels drawing 4½ feet or less, through the Bayou Chef Menteur, into Lake Pontchartrain, and the road along Gentilly Ridge, to the city of New Orleans.

During the past fiscal year operations have been limited to repairs necessary for the preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Tower Dupre's, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This old work is situated at the entrance of Bayou Dupre's into Lake Borgne.

During the past fiscal year operations were confined to such slight repairs as were necessary for the care and preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Battery Bienvenue, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This battery is situated at the junction of two branches of the Bayou Bienvenue, about three miles from its mouth.

A keeper was retained at this work during the year, and, with occasional assistance, kept the work and its buildings in fair condition, and

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also kept the surrounding sea-marsh cleared so as to prevent danger from marsh fires. The battery and buildings have settled so as to be flooded during more than ordinary tides.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Tower at Proctorsville, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—No work was done during the past fiscal year, except that performed by the fort-keeper.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort Jackson, Mississippi River, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work, and Fort Saint Philip, nearly opposite, are situated on the Mississippi River, about 65 miles below New Orleans, and are the most important of those guarding the approaches to New Orleans.

Operations during the past fiscal year consisted in making sally-port to connect lower battery with lower covered-way battery; in providing material for two center-pintle granite platforms; preparing foundations for these; setting a portion of the granite blocks, cutting stone for their permanent breast-height wall, and partially erecting the latter; in raising, bonneting, and resodding magazine-traverses; in repairing slopes of parapet, levees, roads, buildings, and casemates, and general police of the work.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $25,000

During the next fiscal year it is proposed to complete the permanent platforms, with their breast-height walls; enlarge the opening on the lower covered-way battery, and construct a bridge across the moat between the two; take up and relay railroad-track, so as to better facilitate the movement of materials and armament into the fort; construct as much permanent breast-height wall, to replace wooden wall, as the balance of appropriation will permit.

Fort Saint Philip, Mississippi River, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—During the past fiscal year three magazines were built and three traverses completed up to the crown of the arches; foundation of sally-port was completed and weighted; two wooden platforms were put down; foundations prepared for two permanent platforms, and excavations made for seven more. The wharf was extended 32 feet and repaired; a brick drain was built for drainage of magazine in northeast battery. The military reservation was resurveyed, and the boundary-line marked with stone monuments.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $25,000

During the next fiscal year it is proposed to complete the three magazine-traverses in upper battery; complete sally-port and traverse; provide and put down as many permanent platforms and construct as much permanent breast-height wall as the appropriation will permit.

Fort Livingston, Barataria Bay, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This barbette-work is situated on the western end of Grand Terre Island, at the entrance to Barataria Bay. It guards the only approach to New Orleans by vessels drawing 7 feet or less, available on the west side of the Mississippi River. It also secures a safe anchorage and harbor of refuge for our own light-draught coasters in time of war.

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During the past fiscal year no operations have been carried on, except for the care and preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1877.
No appropriation asked for next fiscal year.

Fort at Fort Point, entrance to San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—This is one of the principal works for the defense of the entrance to the harbor of San Francisco, through the Golden Gate, the approaches to this entrance and the inner waters of this passage. The breast-height walls for six heavy guns have been completed, and the concrete foundations for two heavy-gun platforms put in place. A drain has been constructed at south end of battery 6—7. In all, making 475½ cubic yards of masonry. There have been embanked in parapets and traverses 8,365 cubic yards of earth, and there have been placed on the slopes 3,777 square yards of sodding. The doors have been finished and hung in seven traverse-magazines. The usual miscellaneous repairs of buildings, bulkheads, fences, roads, &c., have been made.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $60,000

Fort at Lime Point, San Francisco Harbor, California, in charge of Maj. George H. Mendell, Corps of Engineers.—This fort, with its detached earthen barbette works, at Point Cavallo, Lime Point Ridge, and Gravelly Beach, constitute the defenses of the entrance to the harbor of San Francisco, on the northern shore of the Golden Gate.

No new battery was begun during the year, but operations were confined to placing hoods on the traverses at Point Cavallo battery, and to repairs at the Ridge and Gravelly Beach batteries, together with essential repairs to the roads and to the breakwater.

The platform spaces between the timbers at Gravelly Beach were filled with concrete, consuming 98 yards. The platforms were painted and the terreplein graded. The parapet of one of the guns at the Ridge battery, where there is a heavy filling, having settled, 2,100 yards of material was added. No platforms were laid in this battery, but the timbers for five wooden platforms were prepared for laying.

The hoods and adjacent portions of parapets and slopes in the Point Cavallo battery were sodded. Four thousand yards of earthwork and 2,535 square yards of sodding were laid on the hoods and parapets of the batteries.

To complete these three batteries, there remain to build 7 breast-height walls in Point Cavallo battery and to lay 17 platforms. In the Ridge battery, 5 platforms remain to be laid.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year..... $80,000

Fort on Alcatraz Island, San Francisco Harbor, California, in charge of Maj. George H. Mendell, Corps of Engineers.—This work occupies a valuable position for the defense of the entrance to and the inner waters of the harbor of San Francisco, covering the whole of a rocky island, the shores of which rise abruptly from the water to a height sufficient to secure it from surprise. The fortifications have from their inception consisted chiefly of open barbette batteries for the heaviest guns.

Two magazines and bomb-proofs have been built during the year. One has been covered and sodded and the other nearly covered. Three adjacent wings of the breast-height wall, necessary to sustain the hoods of the traverses, have been built. A part of the sewer from the defensive barrack was rebuilt, it having been broken in the excavation for one

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of the magazines. Two drains in batteries 10 and 12 were also built or extended. The wharf was repaired with new piles.

The principal items of work done in the past year are as follows, namely: Excavation, 36,366 cubic yards; sodding, 876 square yards; plastering, 1,331 square yards; brick masonry, 9 yards, and concrete, 1,150 yards.

The operations of the present fiscal year will be mainly in excavation by prisoners under charge of a kind overseer.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $50,000

Batteries at Point San José, San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—These temporary batteries are in an unserviceable condition; the timber platforms and revetments and timbers of the magazines are rotten and falling to pieces. No work was done during the past fiscal year and none is contemplated during the present year.

Batteries on Angel Island, San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—These three temporary earthworks, constructed during the late war, are essentially unserviceable; the platforms are decayed, and most of the carriages have been condemned. It is not intended to commence the construction of batteries of a permanent character projected to replace them until more advanced points of the exterior line of defense are fortified.

Fort at San Diego, Cal., in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—This work is situated on Ballast Point, near the mouth of the bay and harbor of San Diego, and commands the channel of entrance thereto.

No work was done at this work during the past fiscal year, there having been no appropriation made therefor. A watchman was employed throughout the year to care for the work and public property pertaining thereto. The work and property are in fair condition.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $50,000

Defenses of the mouth of the Columbia River, Oregon, in charge of Maj. N. Michler, Corps of Engineers, until December 28, 1875; *since that date in charge of Maj. John M. Wilson, Corps of Engineers.*—These defenses consist of Fort Stevens, Point Adams, Oregon, on the south side, and Fort Canby, Cape Hancock, Washington Territory, on the north side of the entrance to the river. These works are earthen barbette batteries, and constitute the only defenses of the mouth of the Columbia River.

Fort Canby.—The three batteries require extensive repairs; two of the service-magazines are unfit for use; the wooden revetments and platforms are rapidly decaying; the roads leading to the batteries should be repaired. During the past fiscal year the magazine of the west battery has been rebuilt, two 10-inch-gun platforms in the east battery have been rebuilt, and new revetments placed in front of them.

Fort Stevens.—This work is in a very dilapidated condition; the wooden revetments have badly decayed; the breast-height walls have given way and the traverses are in ruins; the platforms and magazines need repairs, and the drainage of the ditch requires attention. During the past fiscal year a new platform has been constructed for the 15-inch gun and the revetment in front renewed. The revetment has also been renewed in front of one 10-inch and three 8-inch guns, and the earthwork adjacent graded and sodded. Surveys have been made of Sand

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Island, Point Adams, Clatsop Spit, and the swash channel, and charts prepared.

No appropriation was made for the fiscal year ending June 30, 1877.
Appropriation asked for next fiscal year $20,000

BOARDS OF ENGINEERS.

The Board of Engineers for Fortifications, stationed in New York City, consisting of Col. J. G. Barnard, Col. Z. B. Tower, and Lieut. Col. H. G. Wright, and, for the time being, the officer in charge of the defenses under consideration, has, during the past fiscal year, been chiefly engaged upon plans for casemated work with iron shields, to occupy the present site of Fort Lafayette, New York Harbor; for modification of proposed exterior batteries at Fort Taylor, Florida; for revision of proposed batteries at Points Blunt and Knox, and Camp Reynolds, and for occupation of Point San José, San Francisco Harbor, California; for modification of proposed batteries for defense of Dutch Island, Rhode Island; for battery for defense of Tybee Roads, at the mouth of the Savannah River, Georgia; and for barracks at Fort Monroe, Virginia.

Reports have also been made upon the following subjects: Of repairs of injuries to the cover-face of Fort Taylor, Florida, and construction necessary to prevent its further damage by storms; of proposed defenses of Galveston, Tex.; of allowing the use of the Government buildings on Cockspur Island, or of the site for proposed defenses on Tybee Island, Georgia, for the purpose of a naval station; in reference to the adaptation of the Gatling-gun carriage to flank embrasures; as to the disposition of a casemate shield on store at Pittsburgh, Pa.; and of carriage recommended for the 10-inch guns now being converted by the Ordnance Department into 8-inch rifles. Reports and drawings have been submitted showing proposed arrangement of torpedo lines for the harbors of Portland, Me., Portsmouth, N. H., Boston, Mass., New London, Conn., Charleston, S. C., of Patapsco River, Md., Newport Harbor, R. I., Dutch Island, R. I., Potomac River, Md., Hampton Roads, Va., Savannah River, Ga., Pensacola, Fla., Key West, Fla., and Mobile Bay, Ala. During the month of March, 1876, Generals Tower and Wright inspected the defenses at Key West and Tortugas, Fla., "notes" of which inspection were submitted May 3. In addition to the foregoing, the board has had under consideration the defense of the Hussey's Sound entrance to Portland Harbor, Me., and plans of batteries to command this entrance and the inner anchorage are in progress.

TORPEDO DEFENSE.

In this connection, Maj. H. L. Abbot, in command of the engineer battalion and the post of Willet's Point, is *ex officio* a member of the board, and the executive officer by whom the experiments have mainly been made and the details of our system worked out.

In the last annual report so complete a general summary of the scope of the trials now making for the development of the torpedo as an auxiliary in harbor defense was given, that it is only needful here to refer to that paper, and to recapitulate the progress made during the past year.

Experiments with the iron target have been continued with results which may be briefly summed up as follows: Five shots were fired, viz, 50 pounds of dynamite 30 feet below the bottom of target and 5 feet horizontally from one of its angles; 75 pounds 30 feet below the bottom and 8 feet horizontally from an angle; 100 pounds in a position similar

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to the last; 100 pounds 30 feet below the bottom and vertically under an edge; and, lastly, 100 pounds 20 feet below the bottom and vertically under another edge. The last shot sunk the target, and when it was raised and examined, the whole structure was found to be so weakened that extensive repairs have been necessary. The plug indications have been of a character to give much valuable data concerning the several shots, as has been already reported in detail. The target has been put in perfect order and the trials will soon be resumed.

The experiments with the torpedo-crate have been brought to a successful termination, as follows: 30 pounds of dynamite were exploded without doing any injury except deeply corrugating the buoys. Fifty pounds collapsed the latter, as was expected, letting crate down; but it was raised uninjured. It was then placed on the bottom, in 19 feet of water, and 40 pounds exploded without injury. It was again placed on the bottom, in 13 feet of water, and 100 pounds were exploded, effectually breaking up the apparatus. In all these shots the plugs were safely recovered, and their indications, in connection with those of former shots, supply all the data which the experiments were designed to secure.

A series of severe trials of torpedo-cases to determine their strength to resist the blows of large steamers moving at high rate of speed have been carried out with very satisfactory results. All parts of the system perfectly fulfilled their functions. The exact time of each blow was automatically recorded, and the guard was electrically notified not only of each contact, but also whether it caused any injury.

Experiments directed to improving the manufacture of the cases have proved successful, and all bolts and nuts are now avoided in their construction. A perfect disconnecter has been devised by Major Abbot, who has also improved his circuit-closer, so that without extra expense it serves now equally well as a circuit-breaker. Many severe tests have shown it to combine certainty of action with great simplicity and trifling cost.

A ground torpedo, rendered unserviceable by a crack, was planted in the autumn, charged with 200 pounds of dynamite. After remaining submerged for six months, with the charge thoroughly wet, and most of the time frozen, it was fired with tremendous effect on the first trial, the temperature of the water being still below the freezing-point of nitroglycerine.

Several new forms of battery have been subjected to careful measurements, with valuable results, and much other laboratory investigation has been successfully carried out. Incidentally, the general theory of simultaneous ignition of mines has received a mathematical and experimental study, which has developed the principles which should govern the engineer in arranging the connections and determining the minimum battery-power. The value of this investigation for many works of internal improvement is apparent.

Good progress in preparing the Torpedo Manual has been made by Major Abbot, and it is expected that this important work will be completed during the coming season.

In conclusion, the board would repeat its opinion, fully stated last year, that the system of applying torpedoes to harbor defense has now reached so high a degree of perfection, that it is urgently necessary to provide a large number of engineer soldiers instructed in the details of its practical application to our harbors. Not less than 520 men should be kept ready for instant service, a number which is considerably less than the legal organization of the battalion, although larger than the force now authorized to be kept in service.

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For continuing the purchase of such parts of the torpedo-material as cannot suddenly be procured in case of war, an appropriation of $150,000 is recommended.

The Board of Engineers for the Pacific Coast during the past fiscal year has consisted of Lieut. Col. B. S. Alexander, Lieut. Col. C. S. Stewart, and Maj. George H. Mendell. Lieut. Col. R. S. Williamson was assigned as a member of this board by special orders No. 6, dated Headquarters Corps of Engineers, Washington, D. C., January 18, 1876, and has acted in that capacity ever since.

During the year the board has acted and reported upon consideration of project, report and estimate for the improvement of San Diego Harbor; consideration of encroachments of Columbia River and the sea on the shore of Point Adams, threatening the site of Fort Stevens, Oregon; report concerning sea-wall at the city of San Francisco, Cal.; consideration of and report on the filling up of the channels of the Columbia River in the vicinity of Point Adams, Oregon; studies on the subject of a harbor of refuge on the Pacific coast, and report on the value to the United States of certain lands adjacent to San Diego.

BATTALION OF ENGINEERS AND ENGINEER DEPOTS.

Battalion of engineers, commanded by Maj. Henry L. Abbot, Corps of Engineers, headquarters Willet's Point, eastern entrance to New York Harbor.

The strength of the engineer battalion on June 30, 1876, was sixteen comissioned officers and two hundred and forty-eight enlisted men.

The companies were stationed and commanded as follows: At Willet's Point, Company A, Capt. James Mercur; Company B, First Lieut. J. B. Quinn; Company C, Capt. W. R. Livermore; Company D, (a skeleton organization,) First Lieut. Edgar W. Bass, battalion adjutant.

At West Point, Company E, Capt. O. H. Ernst, also instructor in practical engineering at the Military Academy and *ex officio* member of the academic board.

Detachments have served as follows: Department of the Missouri, three non-commissioned officers and four privates; Department of Dakota, two non-commissioned officers and five privates; under Lieutenant Wheeler, on the surveys of the Territories, two privates; at the Centennial Exposition at Philadelphia, one commissioned officer, three non-commissioned officers, and seven privates.

Recruiting has remained discontinued, the only exception being re-enlistments, and enlistments at West Point for Company E to supply vacancies in its numbers. During the year thirteen men were enlisted, thirty-five were re-enlisted, thirteen deserted, and three were apprehended from desertion.

The duties of the battalion have consisted in guarding the depot, and remodeling public buildings at Willet's Point, and receiving and issuing the property as ordered; in instructing the cadets at the Military Academy in field engineering, including military signaling; in experimentally developing the details of the torpedo service, and performing the labor required to carry out the approved project of trials therefor; in drilling in field fortification, military bridge-making, field reconnaissance, photography, target practice, and infantry tactics. The detachments in the Indian country have been employed in military map-making, under the direction of the officers of the corps serving with the troops in those departments, and their efficiency and usefulness have

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received high commendation. During three years, 24,044 miles of reconnaissance have been made and the results mapped by these enlisted men of engineers.

The officers serving with the companies have opportunities not only to learn their military duties in the field, and in planting and operating the torpedo defenses of the coast, but also to acquire familiarity with many other duties of the corps, such as astronomy, hypsometry, current measurements, surveying, &c. In fine, service with the battalion is made to take the place of the more formal schools of application common with other nations in fitting officers for the wide range of duties assigned to the Corps of Engineers.

In our service, as in that of Great Britain and other nations, the duty of devising and perfecting a system of torpedo-defense to be used in combination with the forts, and of practically applying it in case of war, has been assigned to the engineer troops. The legal organization of the battalion, 752 enlisted men, is sufficient to warrant a reasonable expectation that, with the needful material in store, this highly important duty will be satisfactorily performed. Under existing orders issued at the recent reduction of the Army, the force authorized to be kept in service is fixed at 200 men, a number quite insufficient to afford any proper grounds for believing that even our more important sea-ports could be properly protected by torpedoes in time to prevent their destruction. Every effort is now making to thoroughly prepare the men for these duties, which involve long training and higher intelligence than it is common to find in the ranks. Individual records are kept showing the qualifications of each man as determined by his instructors from his regular drills and exercises. But still the fact remains that the force is too small to perform the responsible duties assigned to it, and I therefore feel it my duty to urge that the organization may be recruited to 520 men, the number judged to be the minimum consistent with a reasonable state of preparation for unexpected hostilities. This number is but little more than two-thirds of the maximum fixed by law, and no increase in the legal organization is, therefore, needed.

Engineer post and depot at Willet's Point, New York Harbor, commanded by Maj. Henry L. Abbot, Corps of Engineers.—Willet's Point is the principal engineer-depot of the Army, where are stored, ready for issue, the torpedo-material for the defense of our coast; the bridge-trains and equipage of the Army; siege and mining tools; surveying and astronomical instruments for works of internal improvement and military reconnaissance; and, in general, all reserve supplies for the use of the engineer service. This property is stored in suitable buildings, and is guarded and issued as required, by engineer troops.

The post has become a useful school of application, where officers and men have the needed facilities for learning the practical details of the torpedo service as applied to the defense of harbors and rivers; the ordinary duties of engineer troops in campaign, including military-bridge-making, field fortifications, military reconnaissance, field photography, and infantry tactics, and also many of the civil duties of the corps, such as field astronomy, the measurement of currents, barometric hypsometry, the use of surveying instruments, etc., etc.

The general post and depot buildings are completed, but a fire-proof building for use as a torpedo-laboratory is greatly needed. The importance of an economical use of the funds appropriated for the torpedo service has been steadily kept in view, and the money has been stricty applied to the investigations needful for perfecting the details of the apparatus and to the purchase of the most essential articles for storage

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in case of war. An old wooden carpenter's shop was fitted up as a temporary laboratory; and, in fine, no expenditures on buildings for purposes of instruction or of convenient manipulation have been made. Much valuable apparatus has thus accumulated, where it is in constant danger of destruction by fire. Winter instruction is restricted on account of deficient accommodations, and the time has come when ordinary prudence requires that a suitable building should be provided. The project includes an electrical laboratory, a chemical laboratory, a library-room, a galvanometer-room, a model-operating room, two torpedo-museum rooms, one public and the other confidential, and a cellar for storage of acids, &c. The estimated cost is $20,000; and I urgently request that this amount may be appropriated.

To continue the torpedo trials, inaugurated to perfect the details of this most important branch of sea-coast defense, and for training the engineer troops in practically applying it, an appropriation of $10,000 is asked.

For the purchase of materials for instructing the engineer troops in field engineering, the usual appropriation of $1,000 is asked.

For the incidental expenses of the depot, such as remodeling ponton-trains, repairing instruments, purchasing fuel, forage, stationery, chemicals, extra-duty pay for soldiers engaged in special skilled labor, such as wheelwright work, printing, binding, photographing, and lithographing engineer documents, &c., an appropriation of $3,000 is needed.

Estimate of funds required for Battalion of Engineers and engineer depot at Willet's Point N. Y., for the fiscal year ending June 30, 1878.

For purchase of engineer-materials to continue the present course of instruction of the battalion in field engineering	$1,000
For the incidental expenses of the depot, such as remodeling ponton-trains, repairing instruments, purchasing fuel, forage, stationery, chemicals, extra-duty pay for soldiers engaged in special skilled labor, such as wheelwright work, printing, binding, photographing, and lithographing engineer documents, &c.	3,000
To continue the torpedo trials, inaugurated to perfect the details of this most important branch of sea-coast defense, and for training the engineer troops in practically applying it	10,000
For a fire-proof building for an electrical laboratory, library-room, galvanometer-room, model-torpedo operating-room, confidential torpedo-museum, public torpedo-museum, chemical laboratory, and cellar for storage of acids, &c.	20,000
Total	34,000

RIVER AND HARBOR IMPROVEMENT.

The "act making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," approved March 3, 1875, (Statutes at Large, vol. 18, part 3, page 456,) provided for 156 works of improvement, in sums varying from $1,000 to $500,000, and amounting in the aggregate to more than $6,500,000.

Including the balance of previous appropriations, the sum available on the 1st of July, 1875, for the several works was $8,661,575.52. And during the fiscal year ending June 30, 1876, $6,271,009.19 were expended.

A brief account of each work, together with a money statement giving an estimate of the probable amount required for completion of project, and also the amount that can be profitably expended upon the work during the fiscal year ending June 30, 1878, is given below; but for a more detailed account I beg to refer to the reports of the officers in charge, to be found in the appendix.

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Section 2 of the act required that examinations or surveys, or both, be made at forty-six specified points and localities. Owing to the limited amount of funds it was not practicable to make in all cases such surveys as are necessary for the preparation of projects of improvement with detailed estimates of cost, but in each case an examination or general survey has been made and the results, as far as received, were submitted during the last session of Congress. Some of these reports were printed, but for convenience of reference all are again submitted, and may be found in the appendix.

The act approved March 3, 1875, (Statutes at Large, vol. 18, part 3, page 510,) for the further security of navigation on the Mississippi River, directed that an inquiry be made—

Into the expediency of causing shear-booms to be placed on the upper end of all or any bridge-piers on the Mississippi River, for the better security and convenience of the navigation of said river for rafts of logs and timber, with specific report in each case.

A board of officers of the Corps of Engineers has been constituted and is now engaged upon the consideration of the subject. It is expected that the report will be submitted during the next session of Congress.

Of the amounts appropriated for public works on rivers and harbors by the act approved August 14, 1876, certain allotments have been made in compliance with the instructions of the Secretary of War of September 4, limiting the expenditures under the act to $2,000,000, and directing that no new work of improvement should be begun.

The following statement exhibits these allotments in detail:

Work.	Allotment.	Remarks.
For the improvement of the Boston Harbor, Massachusetts.	$20,000	
For removing obstructions in the East River and Hell Gate, New York.	223,000	
For the improvement of Hudson River	25,000	
For the improvement of the Delaware River below Petty's Island.	35,000	
For the improvement of the Schuylkill River, Pennsylvania.	15,000	
For the construction of piers in Delaware Bay, near Lewes, Del.	1,500	Preservation of materials. An indispensable part of the Delaware breakwater harbor.
For the improvement of the harbor at Baltimore, Md.	40,000	
For the improvement of Cape Fear River, North Carolina.	110,000	
For the improvement of the harbor at Charleston, S. C.	5,000	
For the improvement of the harbor at Savannah, Ga.	25,000	
For the improvement of the mouth of the Mississippi River.	90,000	
For surveys at South Pass of the Mississippi River, in connection with construction of jetties, &c., by James B. Eads.	15,000	
For continuing the improvement on the outer bar at Galveston, Tex.	52,800	
For the improvement of the Mississippi, Missouri, and Arkansas Rivers.	50,000	Snagging and wrecking operations.
For the improvement of the Mississippi River between the mouths of the Illinois and Ohio Rivers.	121,000	
For the improvement of the channel of the Mississippi River opposite the city of Saint Louis, Mo.	25,000	
For the improvement of the Des Moines Rapids, Mississippi River.	115,000	
For the improvement of Rock Island Rapids, Mississippi River.	10,000	

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Work.	Allotment.	Remarks.
For the improvement of the Upper Mississippi River.	$10,000	
For the improvement of the Falls of Saint Anthony, Minnesota.	71,000	
For the annual expense of gauging the waters of the lower Mississippi, its tributaries, &c.	5,000	
For removing raft in Red River and closing Tones Bayou, Louisiana.	35,000	
For the improvement of the Ohio River.....	120,000	
For the improvement of the Tennessee River.	130,000	Muscle Shoals, $115,000. Upper Tennessee, $15,000.
For the improvement of the Great Kanawha River, West Virginia.	15,000	
For the improvement of the Illinois River, Illinois.	10,000	
For the improvement of Oakland Harbor, California.	35,000	
For the improvement of the Lower Willamette and Columbia Rivers.	20,000	
For the improvement of the Fox and Wisconsin Rivers.	120,000	
For the improvement of the harbor at Green Bay, Wis.	3,000	Indispensable to protect the work.
For the improvement of the harbor at Milwaukee, Wis.	5,000	Repair of piers to protect the work.
For the improvement of the harbor at Chicago, Ill.	1,000	
For the improvement of the harbor of refuge, Lake Huron, Michigan.	75,000	
For the improvement of the Saginaw River, Michigan.	11,000	
For the improvement of the harbor at Toledo, Ohio.	22,500	
For a breakwater at Cleveland Harbor, Ohio..	10,000	
For the improvement of the harbor at Erie, Pa.	15,000	
For the improvement of the harbor at Buffalo, N. Y.	45,000	
For the improvement of the harbor at Oswego, N. Y.	25,000	
For the improvement of the Connecticut River below Hartford, Conn.	20,000	
For the improvement of James River, Virginia.	40,000	
For the improvement of the Appomattox River, Virginia.	15,000	
For the improvement of the harbor at Du Luth, Minn.	6,000	Indispensably necessary to protect the piers.
For the improvement of the natural entrance to Superior Bay, Wisconsin.	500	Indispensably necessary to protect the work.
For the improvement of the harbor at Ontonagon, Mich.	1,000	Indispensably necessary to protect the work, and for the safety of navigation.
For the improvement of the harbor at Marquette, Mich.	1,000	Indispensable to protect the breakwater.
For the improvement of the harbor at Ahnapee, Wis.	1,000	Indispensable to protect the work and for the safety of navigation.
For the improvement of the harbor at Two Rivers, Wis.	1,000	Indispensable to protect the work and for the safety of navigation.
For the improvement of the harbor at Manitowoc, Wis.	5,000	Indispensable to protect the work—harbor of refuge.
For the improvement of the harbor of Sheboygan, Wis.	3,000	Indispensably necessary to protect the work.
For the improvement of the harbor of Calumet, Ill.	1,000	
For the improvement of the harbor at White River, Mich.	1,000	Repairs indispensably necessary to preserve the pier.
For the improvement of the harbor at Grand Haven, Mich.	15,000	Essential for the preservation of the channel of entrance and for the safety of navigation.
For the improvement of the harbor at Saugatuck, Mich.	1,500	To secure work already done—the south pier.
For the improvement of the harbor at South Haven, Mich.	3,500	To repair north pier and prevent materia injury to it.
For the improvement of the harbor at Saint Joseph's, Mich.	8,000	For the preservation of the piers and harbor.
For the improvement of Au Sable River, Michigan.	1,000	For the preservation of the work.
For the improvement of the harbor at Sandusky City, Ohio.	12,500	For the safety of existing navigation.
For the improvement of the harbor at Vermillion, Ohio.	1,000	Repairs indispensably necessary.
For the improvement of Fairport Harbor Ohio.	5,000	Repairs indispensably necessary for the preservation of the work.

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Work.	Allotment.	Remarks.
For repair of piers at mouth of Black River, Ohio.	$6,000	Repairs indispensably necessary to preserve the work.
For the improvement of Ouachita River, Arkansas and Louisiana.		
For the improvement of the Yazoo River, Mississippi.	2,000	For preservation of boats, machinery, &c.
For continuing the work of dredging and removing obstructions to navigation in Cypress Bayou, Texas.		
For the improvement of Chester River at Kent Island Narrows, Maryland.	1,000	Repairs indispensably necessary.
For the improvement of the Upper Willamette River, Oregon.	3,000	Absolutely necessary for the preservation of the channel secured by previous work.
For the improvement of the harbor at Michigan City, Ind.	16,000	To secure work already done—harbor of refuge.
For the improvement of the harbor at Burlington, Vt.	6,000	Repairs indispensably necessary.
For the improvement of the harbor at Provincetown, Mass.	4,000	Preservation of the harbor.
For the improvement of the harbor at Oak Orchard, N. Y.	800	

In determining the amounts to be allotted to each work named, reference has been had to the balances on hand of previous appropriations for the works specified.

All these improvements, for the continuance of which parts of the appropriations have been allotted, are, in my judgment, clearly national.

The allotments to the improvements of lesser magnitude and consequence are indispensably necessary to protect work already done.

The officers in charge of the improvements were notified of the amounts allotted, and the works are now being conducted on this basis. Operations have not been commenced upon the new works of improvement provided for in the last river and harbor act.

ATLANTIC COAST.

IMPROVEMENT OF RIVERS AND HARBORS IN THE STATES OF MAINE, NEW HAMPSHIRE, AND MASSACHUSETTS.

Officer in charge, Lieut. Col. George Thom, Corps of Engineers.

1. *Saint Croix River, above the "Ledge," Maine.*—The following appropriations have been made by Congress for the improvement of this river, viz:

By act approved March 2, 1867	$15,000
By act approved March 3, 1873	10,000
By act approved June 23, 1874	10,000
Total	35,000

The act of March 2, 1867, contained the proviso that—

The province of New Brunswick contribute and pay to the proper disbursing officer a like sum for said purpose; said payment being made on condition that in no event shall the province of New Brunswick be called upon for more than half the sum actually expended for said purpose.

An accurate survey was made of this river, under the direction of Lieutenant-Colonel Thom, in 1873, from the "Ledge" up to the toll-gate, between Calais and Saint Stephens, the head of navigation, and a project, with an estimate for its improvement, was submitted by him to both governments; but, owing to the fact that the obstructions to its navigation have been caused by the deposit of the "waste" from the

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saw-mills above, and that no law is in force for preventing the continuance of this evil practice, a correspondence between the department of public works of the Dominion of Canada and the officer in charge of the work has resulted in an agreement to defer any improvement of this channel until they shall become satisfied that this practice shall be permanently discontinued. The attention of Congress is again respectfully asked to this matter, and to the necessity of some general law to protect from injury and obstructions all navigable waters under the control of the United States, and for the improvement of which appropriations have already been or may hereafter be made by Congress.

Amount available July 1, 1875	$34,185 58
Amount available July 1, 1876	34,185 58
Amount (estimated) required for completion of existing project, on the part of the United States	65,000 00

(See Appendix A 1.)

2. *Machias River, Maine.*—The following appropriations have been made by Congress for the improvement of this river, viz:

By act approved March 3, 1873	$12,000
By act approved June 23, 1874	10,000
By act approved March 3, 1875	10,000
Total	32,000

The improvement consisted originally in the removal of a very large and dangerous ledge, (known as Middle Rock,) which seriously obstructed the channel in front of the wharves at Machias, and in the excavation of the several shoals of slabs, edgings, &c., below, so as to obtain a channel 6 feet in depth at mean low-water, (or $19\frac{3}{10}$ feet at ordinary high-water,) from deep water near East Machias bridge up to the wharves at Machias, a distance of 3 miles. This work required 1,350 cubic yards of rock-excavation and 50,000 cubic yards of dredging. A contract was made, June 23, 1873, for the removal of Middle Rock, and on the 28th of July, 1874, its removal was completed down to an average depth of about half a foot below the plane of mean low-water. A contract was made, August 29, 1874, for the partial removal of the Middle Ground, situated about two-thirds of a mile below "the falls;" also for the removal of other shoals above and below the Middle Ground. Another contract was also made, May 13, 1875, for completing the dredging at the Middle Ground and below. On the 1st of July, 1875, the shoal above the Middle Ground had been completed, and some progress made at the Middle Ground. On the 24th of July, 1875, the work contracted for in August, 1874, was completed, whereby the projected channel was excavated through the shoal above the Middle Ground for a length of 850 feet and a width of not less than 100 feet, and through the upper part of the Middle Ground for a length of 800 feet and an average width of 125 feet; the shoal near the draw-bridge, three miles below Machias, was also removed to the extent contemplated. The dredging contracted for in May, 1875, was commenced July 5, 1876, and is to be completed on or before the 30th of September, 1876. The dredging under these two contracts will open a channel, to the depth required, for a width of not less than 100 feet; but as these shoals have been caused chiefly by the slabs, edgings, and saw-dust from the saw-mills at and above Machias Falls, they will, of course, continue to form, so long as the mills shall bepermitted, as at present, to throw their "waste" into the river; so that the improvement now being made will doubtless be but temporary. It is therefore recom-

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mended that no further appropriation be made for continuing the improvement of this river.

It is respectfully recommended that Machias River, Saint Croix River, and all other navigable waters under the control of the United States, for the improvement of which appropriations have been or hereafter may be made by the United States Government, be protected from injury and obstruction by suitable legislation.

Amount available July 1, 1875	$22,011 53
Amount expended during fiscal year ending June 30, 1876	12,661 03
Amount available July 1, 1876	9,350 50

(See Appendix A 2.)

3. *Penobscot River, Maine.*—The work originally projected for the improvement of this consisted—

A. In the enlargement and straightening of its channel through the several bars and shoals at and near Bangor, so as to have a width of not less than 200 feet and a depth of 12 feet at low tide, (25 feet at high tide,) in the lowest stages of the river, giving about 15 feet at low tide in its ordinary stages.

B. In breaking up and removing all the sunken rocks down to the level of the general bed of the river, so as to have not less than 7 feet of water over them in the lowest stages of the river, except "Green's Pier Ledge," so called, which is to have about 5 feet of water over it in those stages, or 8 feet at low tide in its ordinary stages.

At the beginning of the fiscal year, (July 1, 1875,) the projected improvement of all the bars and shoals had been completed, with the exception of the channel through the Middle Ground at Bangor; and all the sunken rocks had been broken up and removed to the extent projected, with the exception of Green's Pier Ledge, and some others discovered in October, 1875.

Contracts have already been made for completing all the dredging on the Middle Ground, and for completing the removal of Green's Pier Ledge, and it is probable that they will all be completed before the close of the present season, leaving only the removal of the recently-discovered ledges to be provided for.

Under the appropriation of $10,000, made by act of March 3, 1875, to be expended for the improvement of the river at and near Bucksport Narrows, (eighteen miles below Bangor,) a survey was made to ascertain the object of the appropriation, which resulted in a project for the improvement of navigation by the removal of the middle ground in front of the wharves at Bucksport to a depth of 12 feet at mean low-water, or 22.3 feet at ordinary high-water. A contract was made for this work, after advertising for proposals therefor, at 12½ cents per cubic yard, and it was completed on the 21st of October, 1875, by 61,910 cublic yards of dredging.

The officer in charge of this work states that the throwing of saw-dust into this river is still continued to a very great extent, and to the serious detriment of its navigation. In view of this, and of the fact that several other navigable rivers in his district, now being improved by the United States Government, are also being injured by the throwing in of slabs, edgings, and saw-dust, by the building of piers and bridge-draws in improper places, and otherwise, he suggests the passage of some general law for the protection and preservation of all navigable waters under the control of the United States Government, for the improvement of which Congress has already or may hereafter make appropriations.

Amount available July 1, 1875	$68,885 18
Amount expended during fiscal year ending June 30, 1876	23,840 90

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Amount available July 1, 1876, including $1,022 due on contracts	$45,044 23
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	6,000 00

(See Appendix A 3.)

4. *Camden Harbor, Maine.*—All the work projected for the improvement of this harbor has been completed during the past fiscal year, being as follows, viz:

Regulating the entrance, by dredging between Portland steamer and Sanford's steamer wharves, and dredging a channel 2,000 feet long, 80 feet wide, and 7 feet deep at mean low-water, (or 16½ feet at mean high-water,) from said entrance up to the upper wharves on the east side of the harbor; and another channel of same depth, and for a width of 80 to 100 feet, connecting with the eastern channel near the lime-kiln wharf, extending up to the head of the harbor on its western side.

In 1873, the eastern channel and the entrance to it were opened to a depth of 7 to 9 feet at mean low-water, and for a width of 50 to 100 feet, extending from the 9-foot curve, near the Portland steamer wharf, up to the head of the wharves on the eastern side of the harbor, altogether a distance of about 2,000 feet. Under the appropriations since made, two contracts were made for completing the dredging, which was accomplished on the 30th of September, 1875, 82,199 cubic yards of dredging having been done under those two contracts, making altogether 104,952 cubic yards of dredging done for the improvement of this harbor and in completion of same.

Amount available July 1, 1875	$19,393 30
Amount expended during fiscal year ending June 30, 1876	19,393 30

(See Appendix A 4.)

5. *Kennebec River, Maine.*—All the work projected for the improvement of this river has been completed, with the exception of the removal of Dry Rock, situated in The Narrows, about one and one-half miles below Richmond. From Richmond up to Gardiner, a distance of eleven miles, the channel has been made safe and navigable for a width of not less than 100 feet and for a depth of 10 feet at low tide (or 15½ feet at high tide) in its lowest summer stages; and from Gardiner to Augusta, a distance of seven miles more, it has also been improved for a width of not less than 100 feet, so as to have not less than 6½ feet at low tide (or 11½ feet at high tide) in the lowest summer stages of the river.

Under a contract made May 6, 1875, for the removal of Dry Rock to a depth of 12 feet at mean low-water, operations have been carried on during the past fiscal year, resulting in the removal of about 375 cubic yards of the rock. This work will probably be nearly, if not quite, completed in the course of the present season, the funds available being sufficient for the purpose.

Amount available July 1, 1875	$28,548 38
Amount expended during fiscal year ending June 30, 1876	733 05
Amount available July 1, 1876	27,815 33

(See Appendix A 5.)

6. *Portland Harbor, Maine.*—All the work projected for the improvement of this harbor has been completed, with the exception of the dredging in front of the harbor commissioners' line above Merrill's wharf; but this work will be done only on condition that the several wharves above Merrill's wharf will be removed so far as they extend beyond the harbor line. The funds now available are sufficient for this purpose.

During the past fiscal year the work done in this harbor has been ap-

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plied to deepening the dock at custom-house wharf, for the benefit of the United States revenue-cutter, in compliance with the request of the Secretary of the Treasury. An accurate triangulation and survey, much needed, has also been made of the wharves and harbor lines.

Amount available July 1, 1875	$47,074 38
Amount expended during fiscal year ending June 30, 1876	2,505 40
Amount available July 1, 1876	44,568 98

(See Appendix A 6.)

7. *Richmond's Island, Maine.*—The improvement projected for this place consists in making a harbor of refuge by means of a rubble-stone breakwater, to connect the island with the main-land. The length of the proposed breakwater is about 2,000 feet, with an average thickness of 25 to 30 feet, and a height of 4 feet above ordinary high-water. During the past fiscal year 4,093 tons of stone have been added to the work, making a total of about 58,143 tons to date. To complete this work in accordance with the original estimate, 10,000 tons more of stone will be needed, for which an appropriation of $15,000 will be required.

Amount available July 1, 1875	$7,269 83
Amount expended during fiscal year ending June 30, 1876	7,269 83
Amount (estimated) required for completion of existing project	15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	15,000 00

(See Appendix A 7.)

8. *Kennebunk River, Maine.*—The work hitherto done for the improvement of this river consists in the extension and repair of the two stone piers at its mouth, and the repair of the United States Government wharf, a short distance above its mouth.

For the entire completion of all the improvements necessary for this river, there remains only the deepening of the channel at the Wading Place and at Mitchell's Point, the estimated cost of which, $5,000, was provided in the act approved August 14, 1876.

Amount appropriated by act approved August 14, 1876	$5,000

(See Appendix A 8.)

9. *Cocheco River, New Hampshire.*—The improvement projected for this river consists in making a channel not less than 40 feet in width and 4 feet in depth at mean low-water (or 10.8 feet at mean high-water) from the Lower Narrows up to the Packet Landing.

The several appropriations made from March 3, 1871, to March 3, 1875, for this river have been applied to the following improvements, viz:

A. The excavation and removal of about 400 cubic yards of ledge at the Lower Narrows, and of numerous sunken rocks which obstructed the channel between the Lower and Upper Narrows, (including Watson's Rocks,) as well as some rocks below the Lower Narrows.

B. Opening a channel through the ledge at the Upper Narrows for a length of 430 feet and for a width of 40 feet and a depth of 4 feet at mean low-water.

C. Opening a channel through the ledge in front of Collins's wharf (above the Upper Narrows) for a length of 260 feet and for a width of 40 feet and a depth of 4 feet at mean low-water.

D. Excavating (by dredging) a channel 40 feet wide and 4 feet deep at mean low-water, from Clement's Point Shoal up to Packet Landing, a distance of about half a mile.

The work done during the past fiscal year has been the opening of a channel through the ledge in front of Collins's wharf, under a contract made May 8, 1875, for the sum of $15,000, which work was completed

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on the 30th of September, 1875; and in 7,108 cubic yards of dredging between Clement's Point Shoal and Packet Landing, under a contract made May 13, 1875, which was completed on the 24th of November, 1875; and in the removal of sunken bowlders and ledges in and near the Lower Narrows.

The work that now remains to be done for completing the improvement of this river, as now projected, consists in the completion of the channel by dredging near Packet Landing, and, where necessary, at the shoals below, and the removal of sunken ledges and bowlders still necessary at and near the Lower Narrows, to effect which will, as estimated, require an additional appropriation of $6,000.

Amount available July 1, 1875	$24,865 98
Amount expended during fiscal year ending June 30, 1876	21,984 42
Amount available July 1, 1876	2,881 56
Amount appropriated by act approved August 14, 1876	14,000 00
Amount (estimated) required for completion of existing project	6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	6,000 00

(See Appendix A 9.)

10. *Merrimac River, Massachusetts.*—All the work projected for improving the falls of this river above Haverhill, Mass., has been completed to the extent now deemed necessary. Newburyport Harbor, at the mouth of the river, has also been improved by the removal of South Gangeway Rock, and of a wrecked schooner; and some progress has been made in the removal of North Gangeway Rock. Between Newburyport and Haverhill the river has been improved by deepening the shoals and the removal of numerous bowlders (including Little Currier Rock) which obstructed the channel above and below Rocks Bridge. During the past fiscal year the river below Rocks Bridge has been further improved by the removal of Petty Rock and a large number of other dangerous rocks. Some progress has also been made, under the contract of May, 1875, in the improvement, by dredging, of Currier's Shoal, about 4 miles below Haverhill, with a probability of its completion about the end of July. After its completion the balance then available will be applied to other projected improvements between Newburyport and Haverhill. For completing the removal of North Gangeway Rock and improving the Boilers in Newburyport Harbor an additional appropriation of $25,000 will be required.

Amount available July 1, 1875	$13,163 55
Amount expended during fiscal year ending June 30, 1876	2,703 01
Amount available July 1, 1876	10,460 54
Amount (estimated) required for completion of existing project	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	25,000 00

(See Appendix A 10.)

11. *Gloucester Harbor, Massachusetts.*—Under the appropriation of June 10, 1872, the removal of the following sunken rocks has been completed, viz: Clam Rock, Pinnacle Rocks, rocks off J. Friend's wharf, rock off Pew's wharf, and Babson's Ledge, to the extent projected.

Amount available July 1, 1875	$686 84
Amount expended during fiscal year ending June 30, 1876	579 10
Amount available July 1, 1876	107 74

(See Appendix A 11.)

Salem Harbor, Massachusetts.—The work projected for the improvement of this harbor consisted in the excavation, by dredging, of a channel 1,730 feet long and 300 feet wide to a depth of 8 feet at mean low-water (or 17.3 feet at mean high-water) from deep water to the entrance

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of South River; and for the building of a sea-wall and breakwater for the protection and preservation of Long Point. Under the appropriation of March 3, 1873, this channel was opened for a width of about 160 feet, and under that of June 23, 1874, it has been completed to the projected width of 300 feet. To complete the sea-wall and breakwater, which are comparatively unimportant works, will require an additional appropriation of $23,000.

Amount (estimated) required for completion of existing project $23,000
Amount that can be profitably expended in fiscal year ending June 30, 1878.... 23,000

(See Appendix A 12.)

13. *Boston Harbor, Massachusetts.*—The following is a statement of the present condition of the several works completed, projected, and in progress for the improvement of this harbor, and the progress made upon them during the fiscal year, viz:

A. *Sea-wall on Point Allerton.*—This wall was completed in May, 1874, together with a riprap apron-work for the protection of its foundation. Its total length is 1,202 feet. It is now in excellent condition in every respect, and fully answers the purpose intended.

B. *Sea-wall on Great Brewster Island.*—This wall is 2,840 feet in length, and was built for the protection of the north and south heads of that island, having been completed in 1870. It is in good condition, and requires but few repairs.

C. *Sea-walls on Lovell's Island.*—The two sea-walls on this island were built by the United States Government, one in 1843, for the protection of its north head, and the other in 1867–'68, for the protection of its southeast bluff, for a length of about 800 feet. For the protection of the shore-line next south of the north head wall, and next south of the southeastern wall, apron-work and jetties of rubble-stone were added, in 1873. The wall on the southeast bluff has been much damaged by recent storms, and it is recommended that its height be increased 4 feet by adding two more courses, and that it be otherwise repaired, at a probable cost of $15,000. The other wall and apron-work are now in good condition, requiring no repairs, and fully answer the purpose intended.

D. *Sea-wall on Gallop's Island.*—This wall was commenced in 1868, and completed in September, 1871. It is 1,785½ feet in length, and has its foundation protected for nearly its whole extent by a riprap apron-work and stone jetties, which were added in 1873–'74. This work is in good condition, and fully answers in every respect the purpose for which it was intended.

E. *Sea-wall on the north head of Long Island.*—This wall was commenced in 1870, and completed in the latter part of July, 1874, to a total length of 2,081¾ feet. For the protection of its concrete foundation, a riprap apron, with jetties, has been built on those parts where most exposed to injury by storms and currents, having been completed early in August, 1874. This work is in good condition, requiring no repairs, and fully answers the purpose intended.

F. *Sea-walls on Deer Island.*—The three sea-walls on this island were built about 35 years ago, for the protection and preservation of the north, middle, and south heads, and were respectively 1,740, 840, and 380 feet in length. The injury which these walls had sustained from the violence of the storms was such as to necessitate the rebuilding of them to a great extent. This was commenced in 1865, and completed in 1869. The violent storms of the past winter and spring have, to some extent, injured this wall at the north head, which will have to be repaired.

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G. *Straightening, widening, and deepening the main ship-channel at the west end of Great Brewster Spit.*—This work consists in the removal, by dredging, of the southern portion of this spit, so as to give to the channel a width of 600 feet for a depth of 23 feet at mean low-water. Under a contract made in September, 1874, the dredging, which was commenced in October, 1874, was completed in August, 1875. During these operations a ledge was laid bare, of which 112½ cubic yards will have to be broken up and removed for obtaining the required depth of 23 feet at mean low-water. Some progress has been made in the removal of this ledge under the contract of September, 1874, with a probability of its completion in September next, (1876.)

H. *Straightening, widening, and deepening the main ship-channel at the southeast and southwest points of Lovell's Island.*—This improvement consists in widening the channel so as to have a width of 600 feet for a depth of 23 feet at mean low-water. Under the appropriation of June 23, 1874, a contract was made in September, 1874, for the dredging at the southeast point of this island. Work under this contract was commenced in October, 1874, and was completed in September, 1875. For completing the improvement at the southwest point of this island an additional appropriation will be required.

I. *Straightening, widening, and deepening the main ship-channel at the Upper Middle Bar.*—The improvement projected for this bar consists in excavating a channel to a width of 600 feet and for a depth of 23 feet at mean low-water, the mean rise and fall of the tide being 10 feet. Dredging operations were commenced on the bar in 1870, and have been continued, with intervals of suspension, for want of funds, up to the present time. During the past fiscal year work has been carried on under three separate contracts, (one made March 5, 1874, one September 1, 1874, and the other May 19, 1875,) by which, with the dredging previously done, a channel has been opened, to the required depth, for an average width of 450 feet. For completing the work on this bar and the continuous shoals below it to the projected width and depth, will require about 90,000 cubic yards more of dredging (65,000 of which are already contracted for) and the breaking up and removal of some recently-discovered ledges.

J. *Removal of Nash's Rock, (Shoal.)*—This shoal lies in the entrance to Boston Harbor, about one-third of the way over from Brewster Spit to Point Allerton. By a survey made in 1873, under the direction of the engineer officer now in charge, it was ascertained that this shoal (previously known as Nash's Rock) is covered with bowlders, shingle, gravel, &c., and has an area of about 640 superficial yards with less than 21 feet of water over it at mean low-water, and an area of about 9 acres with less than 23 feet of water over it. The improvement here projected consists in its removal to a depth of 21 feet at mean low-water, for which a contract was made May 19, 1875, the work to be completed on or before the 30th of September, 1876.

K. *Removal of Kelly's Rock.*—This rock lies in the main ship-channel, distant about 700 yards in a direction southeast by south from Bug Light, (at "the Narrows,") and in the line of the entrance-buoy No. 1 and Bug Light, and has always been a very dangerous obstruction to navigation. In 1869 work was commenced upon the removal of this ledge to the depth of 23 feet at mean low-water, and was continued up to the end of 1870, leaving, as shown by surveys since made, a large area not having the required depth. Under the appropriation of March 3, 1875, a contract was made May 14, 1875, for completing the removal of this rock. Work was commenced under this contract in the latter part of

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May, and was satisfactorily completed in September, 1875. During these operations of 1875, new ledges were discovered in the vicinity of Kelly's Rock, above and below it, having on the shoalest parts a depth of 20 to 21 feet at mean low-water. To reduce them to the projected depth of 23 feet at mean low-water, will require 189 cubic yards of excavation, at an estimated cost of $11,340, for which an additional appropriation will be required.

L. *Removal of Tower Rock.*—This rock was situated in the main ship-channel at the Narrows, about 100 yards to the southwest of Great Brewster Spit Light. It was blasted out and removed in 1867 to the projected depth of 23 feet at mean low-water.

M. *Removal of Corwin Rock.*—This rock was situated in the main ship-channel at the Narrows, about 200 yards to the southwest of Great Brewster Spit Light. It was blasted out and removed in the years 1868 and 1869 to the projected depth of 23 feet at mean low-water.

N. *Removal of sunken ledge between George's Island and Great Brewster Spit.*—This ledge was discovered in September, 1872, in a resurvey of "the Narrows" made under the direction of the engineer officer now in charge. It was situated near the middle of the main ship-channel, distant about 317 yards in a direction west by south from Bug Light. It had but 18.9 feet of water over it at mean low-water, and was consequently a dangerous obstruction to navigation for the European steamers and other large vessels. Under a contract made August 31, 1874, the removal of this ledge was completed in September, 1874, to the projected depth of 23 feet at mean low-water.

O. *Removal of Barrel Rock in Broad Sound.*—This was a bowlder lying about 1 mile a little north of west from Green Island, and near the sailing line of the Portland and other Maine steamers. It had only 4 feet of water over it at low tide, and in thick weather was a dangerous obstacle to navigation. It was removed in 1869.

P. *Removal of State and Palmyra Rocks.*—By a survey made in 1873, under the direction of the engineer officer now in charge of this work, it was ascertained that these dangerous rocks, the position and character of which had previously been but little known, consisted of bowlders and ledges lying on the southern spurs of the "Lower Middle," which ocean steamers and other large vessels had occasionally struck. Under a contract made August 31, 1874, for the removal of these sunken rocks, work was commenced upon them in September, 1874, and on the 15th of June, 1875, their removal was completed.

Q. *Removal of wreck of Schooner Delos.*—This vessel was sunk in 1872 in Nantasket Roads, about 100 yards from Fort Warren wharf, in about 22 feet of water at mean low-water, and was broken up and removed in May and June, 1873.

R. *Improvement of Hingham Harbor, Massachusetts.*—In the appropriation for Boston Harbor, made by act of March 3, 1875, provision was made for the improvement of Hingham Harbor, Massachusetts, to an extent not exceeding in cost $10,000. The project for its improvement consisted in widening and deepening the main channel so as to have a width of not less than 100 feet and a depth of 8 feet at mean low-water (or about 6 feet at low-water in spring tides) up to the wharves of Hingham, requiring 25,160 cubic yards of dredging and 80 cubic yards of ledge excavation. This work has been completed at a cost of $9,116.58.

From the report of the engineer officer in charge it is seen that nearly all the works hitherto projected for the improvement of Boston Harbor

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have been completed, and that the following only remain to be completed, viz:

a. The removal of a recently-discovered ledge near the southwestern extremity of Great Brewster Spit. Work has been commenced upon this ledge by contract, and it is probable that it will be completed in September, 1876.

b. About 40,000 cubic yards of dredging at the southwest point of Lovell's Island, in order to obtain the contemplated width and depth of channel, for which no funds are now available.

c. About 90,000 cubic yards of dredging at the Upper Middle Bar, for obtaining a channel to the projected width of 600 feet and a depth of 23 feet at mean low-water. A contract has been made for 65,000 cubic yards of this dredging, to be completed this season, leaving only 25,000 cubic yards to be provided for by future appropriations.

d. Removal of Nash's Rock, (Shoal.)—This work has not yet been commenced; but a contract has been made requiring it to be completed on or before the 30th of September next.

e. The removal of about 189 cubic yards of sunken ledges, discovered in 1875, in the vicinity of Kelly's Rock, for which no funds are now available.

In addition to the above, the southeastern sea-wall on Lovell's Island will require raising and repairing; and some few repairs are needed by the sea-walls on Great Brewster Island and Deer Island, for which no funds are now available.

Amount available July 1, 1875	$191,930 78
Amount expended during fiscal year ending June 30, 1876	111,475 49
Amount available July 1, 1876, including $17,811.28 due on contracts	80,455 29
Amount appropriated by act approved August 14, 1876	50,000 00
Amount (estimated) required for completion of existing project	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	25,000 00

(See Appendix A 13.)

14. *Plymouth Harbor, Massachusetts.*—The several appropriations heretofore made for this harbor have been applied to the construction of bulkheads, jetties, and groins for the preservation and strengthening of Long Beach, upon which the harbor depends for its existence. During the past year these works have been repaired and strengthened where most necessary, being now in a very good and effective condition. Repairs will, however, be required hereafter upon these works from year to year as heretofore, for which Congress will continue to be called upon for suitable appropriations.

By act of March 3, 1875, the sum of $10,000 was appropriated for this harbor, to be applied in part to improving the harbor itself. The project adopted consists in opening by dredging a channel leading from the middle ground up to the wharves of Plymouth, to a depth of 6 feet at mean low-water, or 16 feet at mean high-water, and for a towing width of 100 feet. Under a contract made May 13, 1875, dredging operations were commenced in April and finished in June, 1876, resulting in 34,985 cubic yards in completion of the contract, by which the projected channel has been opened for a width of 50 feet and to the depth required. For completing this channel as now recommended by the engineer in charge, and for the annual repairs of the works built for the preservation and protection of Long Beach, an additional appropriation of $30,000 will be required.

Amount available July 1, 1875	$11,075 67
Amount expended during fiscal year ending June 30, 1876	10,748 25
Amount available July 1, 1876	327 42
Amount (estimated) required for completion of existing project	30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	30,000 00

(See Appendix A 14.)

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15. *Provincetown Harbor, Massachusetts.*—The several appropriations heretofore made for the preservation and improvement of this harbor have been applied to the construction of the following works, viz:

A. Bulkheads and jetties of various descriptions have been built from time to time along Beach Point, for its preservation and protection, both by the United States Government and by the local authorities.

B. A dike was built in 1868 and 1869 by the State of Massachusetts across the outlet of East Harbor Creek.

C. A dike was built in 1868 and 1869 by the United States Government across East Harbor Creek, at the Wading Place, near High Head, about 2 miles above the outlet of the creek.

D. Wooden bulkheads and jetties have been built at different times for the protection and preservation of the beach on Long Point.

E. A stone bulkhead has been nearly completed for the protection and preservation of the outer end of Long Point, the light-house, and three-gun battery.

F. A substantial dike (272 feet in length) was built in 1871–'72 across the head of Lancey's Harbor, near Abel Hill.

G. Beach-grass planted on Beach Point, Long Point, Abel Hill, Cove Section, and Oblique Section, and at the last two places brush has also been laid for their further protection.

H. The projected extension of the several jetties on Beach Point and State Dike has been completed.

I. A bulkhead and 6 jetties built for the preservation and protection of the beach at Cove Section, near High Head, were encroached upon by the extraordinary gales of November, 1873, and January, 1874. This bulkhead is 607 feet in length, and the jetties have an aggregate length of 126 feet. They consist of a frame-work filled with brush and ballasted with stone, and were completed in December, 1874.

J. Accurate resurveys made in 1871–'72–'73 and '74 of Cove Section, Oblique Section, Beach Point, and Long Point, together with elaborate soundings and current observations in the inner harbor.

On the 1st of July, 1875, there was available for the further improvement of this harbor the sum of $3,326.07; amount expended during the fiscal year ending June 30, 1876, $2,830.

The amount expended during the fiscal year ending June 30, 1876, has been applied to the completion of the sluice-way and other repairs of High Head Dike; to strengthening and extending the bulkhead and jetties at Cove Section, repairing bulkhead and jetties on Beach Point, extending the stone bulkhead on Long Point, and planting beach-grass at Cove Section, Olique Section, Beach Point, Long Point, and on the sand-hills between Beach Point and Cove Section. These works and all the others built for the preservation and protection of this harbor require continuous watching and repairs, for which and for an extension of the stone bulkhead on Long Point the additional sum of $5,000 will be required for the next fiscal year.

Amount available July 1, 1875	$3,326 07
Amount expended during fiscal year ending June 30, 1876	2,830 00
Amount available July 1, 1876	496 07
Amount appropriated by act approved August 14, 1876	4,000 00
Amount (estimated) required for completion of existing project	1,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	1,000 00

(See Appendix A 15.)

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EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Lieutenant-Colonel Thom was charged with, and has completed during the past fiscal year, the following examinations and surveys, provided for by act of March 3, 1875:

1. *Belfast Bay and Harbor, Maine.*
2. *Harbor Matinicus Island, Maine.*
3. *Ipswich River and Harbor, Massachusetts.*

The several reports upon these surveys have been transmitted to Congress, and printed in Ex. Doc. No. 71, Forty-fourth Congress, 1st session.

(See Appendixes A 16, A 17, and A 18.)

IMPROVEMENT OF THE HARBORS OF HYANNIS, WAREHAM, NEW BEDFORD, AND FALL RIVER, MASSACHUSETTS, AND OF WICKFORD AND NEWPORT HARBORS, RHODE ISLAND; CONSTRUCTION OF BREAKWATER AT BLOCK ISLAND; IMPROVEMENT OF TAUNTON, PAWTUCKET, PROVIDENCE, AND PAWCATUCK RIVERS, AND OF CONNECTICUT RIVER, INCLUDING SAYBROOK BAR.

Officer in charge, Maj. G. K. Warren, Corps of Engineers.

1. *Hyannis Harbor, Massachusetts.*—There being no funds available for this work, nothing was done during the past fiscal year. To complete the strengthening of the work at the breakwater will require an appropriation of $10,000.

Amount available July 1, 1875	$42 94
Amount available July 1, 1876	42 94
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	10,000 00

(See Appendix B 1.)

2. *Wareham Harbor, Massachusetts.*—The continuation of the dredging under the last appropriation was unavoidably delayed until June, 1876. It has since been completed. There is now a channel up to the wharves 9 feet deep at mean low-water, having a width of 100 feet in the narrowest part, and throughout the greater part of the harbor not less than 200 feet. The mean rise of the tide is about 4 feet.

Amount available July 1, 1875	$9,998 95
Amount expended during fiscal year ending June 30, 1876	2,974 17
Amount available July 1, 1876, including $244.83 due on contracts	7,024 78

(See Appendix B 2.)

3. *New Bedford Harbor, Massachusetts.*—In the season of 1875 a channel 105 feet wide was dredged from deep water near Fair Haven wharves, across the shoal, to the wharves at New Bedford. The depth secured was 15 feet at mean low-water. The mean rise of the tide is about 3 feet. To complete this channel to the width of 200 feet will, according to the original estimate, require an additional appropriation of $14,000.

Amount available July 1, 1875	$9,699 49
Amount expended during fiscal year ending June 30, 1876	9,625 62
Amount available July 1, 1876	73 87
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	4,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	4,000 00

(See Appendix B 3.)

4. *Taunton River, Massachusetts.*—The work under the appropriation of March 3, 1875, consisting of dredging and removing rocks from the

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channel, has been completed. There are yet shoal places to be deepened and scattering rocks to be removed, which will require an additional appropriation of $5,000. The channel is now essentially 9 feet deep at mean high-water; in the narrowest cuts 45 feet wide, and in others 60 feet wide. The river is not navigable at low tide in the upper part.

Amount available July 1, 1875	$9,856 84
Amount expended during fiscal year ending June 30, 1876	8,650 94
Amount available July 1, 1876	1,205 90
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	5,000 00

(See Appendix B 4.)

5. *Fall River Harbor, Massachusetts.*—The work under the last appropriation has completed the projected channel to a width of 100 feet and depth of 12 feet at mean low-water. The mean rise of the tide is about 4.7 feet.

The original project contemplates a gradual widening of this new channel to 300 feet at each end, for which $5,000 will be required.

Amount available July 1, 1875	$14,386 77
Amount expended during the fiscal year ending June 30, 1876	13,789 22
Amount available July 1, 1876	597 55
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	5,000 00

(See Appendix B 5.)

6. *Pawtucket River or Seekonk River, Rhode Island.*—During the past fiscal year the dredging required in this river was completed. The improved channel has a least width of 75 feet, and a depth of 7 feet at mean low-water. The mean rise of the tide is 4½ to 5 feet. At Dunnell's, Bass Rock, and Swan Point, where there is a tendency to fill, the depth was dredged to 9 feet at mean low-water. The stones and piles of an old bridge, which obstructed the east opening of the pivot-draw of the new bridge, were removed.

Amount available July 1, 1875	$7,544 83
Amount expended during fiscal year ending June 30, 1876	5,950 22
Amount available July 1, 1876	1,594 61

(See Appendix B 6.)

7. *Removal of Bulkhead Rock, Providence River, Rhode Island.*—Under an appropriation of $2,500 in 1870, this rock was reduced so as to give a depth of 14 feet at mean low-water. Mean rise of tide is about 4½ feet. The safety of vessels requires that there should be a depth of 18 feet at mean low-water over this rock, for which $5,000 will be required.

Amount available July 1, 1875	$74 98
Amount available July 1, 1876	74 98
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	5,000 00

(See Appendix B 7.)

8. *Wickford Harbor, Rhode Island.*—Work during the past fiscal year consisted in dredging in the inner part of the harbor, to straighten the channel. No further improvement is required at present, except in the way of facilitating the approaches, by means of a beacon on James Ledge, and a change of the light-house to the vicinity of Old Gay Rock. This harbor is now used as part of the daily route of passengers and mail between Newport and New York, and requires facilities not form-

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erly demanded. There is now a draught of from 9 to 10 feet at mean low-water into the harbor. The mean rise of the tide is about 3.7 feet.

Amount available July 1, 1875	$1,452 24
Amount expended during fiscal year ending June 30, 1876	1,452 24

(See Appendix B 8.)

9. *Newport Harbor, Rhode Island.*—The dredging during the past fiscal year has completed the project originally made, with the exception of the cut through the shoal between Lime Rock and Goat Island, where it was designed to increase the depth from 12½ feet to 15 feet at mean low-water for a width of 300 feet. The material was, however, found so hard that a cut of only 45 feet in width could be made. This work, with the removal of the sand-shoal at the southeast of Goat Island, and the construction of the jetty on the island to arrest the sands, exhausted the first appropriation of $8,500. The two subsequent appropriations of $10,000 each have been used in dredging a channel along the harbor line and two approaches to the wharves. The depths in these channels vary from 13 feet to 10 feet at mean low-water, and widths from 250 feet to 50 feet, depending upon the importance of the locality. The mean rise and fall of the tide is about 3¾ feet. Further dredging would increase the anchorage in the harbor, which is much used as one of refuge in storms and adverse winds. The amount unexpended will be needed to mark the channel and close up the work.

Amount available July 1, 1875	$11,396 42
Amount expended during fiscal year ending June 30, 1876	10,442 36
Amount available July 1, 1876	954 06

(See Appendix B 9.)

10. *Block Island Breakwater, Rhode Island.*—The condition of this work is substantially as reported in the last annual report. There not being sufficient funds available to proceed advantageously with the construction, work was suspended until such time as the proper amount should be secured. The next work to be done is the building of a detached breakwater, to guard against northeast storms. This will cost about $60,000. When begun it should be built rapidly, without interruption, for, in a partially finished state, it would be of little benefit, and might prove a very dangerous obstruction.

Amount available July 1, 1875	$26,449 53
Amount expended during fiscal year ending June 30, 1876	4,001 83
Amount available July 1, 1876	22,447 70
Amount appropriated by act approved August 14, 1876	40,000 00

(See Appendix B 10.)

11. *Pawcatuck River, Rhode Island and Connecticut.*—During the past fiscal year this improvement was completed, the wharf-owners at the head of navigation contributing to extend the dredging in front of their wharves. There is now 5½ feet depth at mean low-water throughout, with a dredged channel not less than 75 feet in width up to Swann's wharf in Westerly. The mean rise of the tide is about $2\frac{3}{10}$ feet.

Amount available July 1, 1875	$9,793 34
Amount expended during fiscal year ending June 30, 1876	9,616 97
Amount available July 1, 1876	176 37

(See Appendix B 11.)

12. *Connecticut River below Hartford, Conn.*—During the low-water succeeding the freshet in 1875, shoals became troublesome at Hartford Bar, Pratt's Ferry Bar, and Glastonbury Bar, at which places dredging was done so as to secure a depth of 9 feet at low tide.

A considerable extension was made to the east jetty over Saybrook

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Bar, at the entrance of the river into Long Island Sound. So far this jetty has given no increase of depth for navigation, as it continues shoal beyond the end of the jetty, and probably will continue so until the structure reaches beyond the crest of the bar and meets the deep water and strong littoral current occasioned by the Sound tidal currents.

To complete this jetty $45,000 is required, which can only be done economically by having the amount in one appropriation. About $5,000 will be annually required for dredging in the river.

Amount available July 1, 1875	$19,705 61
Amount expended during fiscal year ending June 30, 1876	19,540 19
Amount available July 1, 1876	165 42
Amount appropriated by act approved August 14, 1876	20,000 00
Amount (estimated) required for completion of existing project	35,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	35,000 00

(See Appendix B 12.)

13. *Connecticut River, above Hartford and below Holyoke, Connecticut and Massachusetts.*—There has been no low water during the past fiscal year to require any expenditures to aid navigation on this portion of the river.

The results of the surveys of former years have been prepared for publication. Some interesting results of measurements on the resistances of cords of different sizes to currents of different velocities are given in Appendix B 13 of this report. There have been three appropriations for this part of the river, which have been but partially expended.

Above Hartford and below Enfield Falls.

Amount available July 1, 1875	$12,272 04
Amount available July 1, 1876	12,272 04

Above Enfield Falls and below Holyoke.

Amount available July 1, 1875	10,702 92
Amount available July 1, 1876	10,702 92

Above Hartford and below Holyoke.

Amount available July 1, 1875	6,606 65
Amount expended during fiscal year ending June 30, 1876	2,774 82
Amount available July 1, 1876	3,831 83

(See Appendix B 13.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of March 3, 1875, Major Warren was charged with the following, the results of which were transmitted to Congress in a report which was printed in H. R. Ex. Doc. No. 70, 44th Cong., 1st session.

Survey of Little Narragansett Bay, Rhode Island and Connecticut.—(See Appendix B 14.)

HARBORS ON LONG ISLAND SOUND.

Officer in charge, Maj. J. W. Barlow, Corps of Engineers.

1. *Stonington Harbor, Connecticut.*—The dredging of the northern half of Penguin Shoal to a depth of 12 feet at mean low-water has been completed, increasing the area of anchorage-ground about 22 acres.

The new breakwater was begun and 770 feet built by contract, com-

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mencing at its northwest end, in 35 feet water. This work will extend from the vicinity of Wampassett Point (the west point of entrance from Fisher's Island Sound) in a general southeasterly direction for a length of about 2,000 feet.

Amount available July 1, 1875	$37,489 52
Amount expended during fiscal year ending June 30, 1876	36,529 77
Amount available July 1, 1876	959 75
Amount (estimated) required for completion of existing project	206,536 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

(See Appendix C 1.)

2. *New Haven Harbor, Connecticut.*—The appropriation of March 3, 1875, is being applied to widening the channel between Long wharf and Belle dock to 400 feet, with a depth of 13 feet at mean low-water.

In answer to a resolution of the House of Representatives of January 21, 1875, estimates were prepared by the officer in charge for the enlargement of the channel of this harbor and for the construction of a breakwater to afford a secure anchorage in stormy weather. These estimates were submitted in my last annual report. Should Congress see fit to approve this project, the sum of $150,000 could be profitably expended during the next fiscal year.

Luddington Rock.—A small portion of this rock still remains above the plane of removal. The amount so left is quite small, and will be removed this season. No additional appropriation is required.

Amount available July 1, 1875	$16,237 29
Amount expended during fiscal year ending June 30, 1876	4,539 95
Amount available July 1, 1876, including $2,496.21 due on contracts	11,697 34

(See Appendix C 2.)

3. *Milford Harbor, Connecticut.*—The work during the past year has been the construction of a jetty to concentrate the effect of the water from Indian River and the dredging of a channel 100 feet wide and 4 feet deep through the bar at the upper end of the harbor.

The contract for the latter work is not yet completed. It is desired to continue this channel to the town docks, and for this purpose $9,000 is asked.

The estimate for the completion of the breakwater is $55,000.

Amount available July 1, 1875	$13,059 11
Amount expended during fiscal year ending June 30, 1876	8,352 46
Amount available July 1, 1876, including $1,399.95 due on contracts	4,706 65
Amount (estimated) required for completion of existing project	64,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	64,000 00

(See Appendix C 3.)

4. *Housatonic River, Connecticut.*—The work at this place during the past fiscal year has been with a view to restoring the seven-foot channel in such places as had become shoal.

Ten thousand dollars will be required to keep the channel open to seven feet depth during the ensuing year.

Amount available July 1, 1875	$8,950 05
Amount expended during fiscal year ending June 30, 1876	4,489 94
Amount available July 1, 1876	4,460 11
Amount that can be profitably expended in fiscal year ending June 30, 1878.	10,000 00

(See Appendix C 4.)

5. *Bridgeport Harbor, Connecticut.*—A channel of 12 feet depth at mean low-water has been dredged to a width of 100 feet, extending from the head of the harbor to Long Island Sound.

An increase of the width of this channel to 200 feet, it is estimated, will cost $25,000.

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Amount available July 1, 1875	$22,817 09
Amount expended during fiscal year ending June 30, 1876	22,762 24
Amount available July 1, 1876	54 85
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	25,000 00

(See Appendix C 5.)

6. *Southport Harbor, Connecticut.*—A coping has been built on the breakwater, increasing its height 2 feet. This, with a fence 135 feet long and 2½ feet high, it is expected will prevent the sand washing over into the channel.

No appropriation is asked for the next fiscal year.

Amount available July 1, 1875	$5,000 00
Amount expended during fiscal year ending June 30, 1876	4,616 01
Amount available July 1, 1876	383 99
Amount appropriated by act approved August 14, 1876	5,000 00

(See Appendix C 6.)

7. *Norwalk River, Connecticut.*—The channel below the wagon-bridge at South Norwalk has been widened to 100 feet, and the channel 60 feet wide has been made continuous from the wagon-bridge to Norwalk.

It is proposed to widen this upper channel to 100 feet, at an estimated cost of $30,000, and for this purpose $15,000 is asked for the next fiscal year.

Amount available July 1, 1875	$12,566 94
Amount expended during fiscal year ending June 30, 1876	12,376 32
Amount available July 1, 1876	190 62
Amount (estimated) required for completion of existing project	30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	15,000 00

(See Appendix C 7.)

8. *Port Jefferson Harbor, Long Island, New York.*—During the past fiscal year a jetty 475 feet long has been built on the west side of the entrance with a beneficial result already evident. It is desirable to extend this jetty and to repair and lengthen the one on the east side.

For these purposes $20,000 can be profitably expended.

Amount available July 1, 1875	$15,988 37
Amount expended during fiscal year ending June 30, 1876	4,982 14
Amount available July 1, 1876, including $2,022.90 due on contracts	11,006 23
Amount appropriated by act approved August 14, 1876	6,000 00
Amount (estimated) required for completion of existing project	22,250 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	20,000 00

(See Appendix C 8.)

9. *Peconic River, Long Island, New York.*—No work was done on the improvement of this river during the past fiscal year. The dredged channel remains in good condition.

There is a balance of $285.45 of the appropriation of March 3, 1873.

(See Appendix C 9.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of March 3, 1875, Major Barlow was charged with the *survey of the channel of West Haven Harbor, Connecticut.* For his report thereon see Appendix C 10.

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IMPROVEMENT OF HUDSON RIVER—REMOVAL OF OBSTRUCTIONS IN EAST RIVER, INCLUDING HELL GATE—IMPROVEMENT OF HARLEM RIVER AND EAST CHESTER CREEK, AND OF THE HARBORS OF PORT CHESTER AND RONDOUT, IN NEW YORK—PASSAIC RIVER AND THE CHANNEL BETWEEN STATEN ISLAND AND NEW JERSEY—HARBORS ON LAKE CHAMPLAIN.

Officer in charge, Lieut. Col. John Newton, Corps of Engineers, who has under his immediate orders Capt. W. H. Heuer and Lieut. J. H. Willard, Corps of Engineers.

1. *Improvement of Hudson River, New York.*—The operations during the fiscal year have been as follows:

1. Surveys were made and maps constructed of Round and Fish-house Shoals, Cuyler's Bar, Old State Dam, Winnie's Bar, Cedar Hill Bar, Coeymans, New Baltimore, and Overslaugh.

2. At New Baltimore there were begun and finished—

Of the new dike	2,914 feet.
Of the cross dike	314 feet.

3. Five thousand cubic yards were dredged from channel at New Baltimore, 7,000 cubic yards from Cedar Hill Bar, and 12,000 cubic yards from Coeymans Bar.

4. Repairs were made to crib-dikes at Hill House, Base and Patroon's Islands, the Bath, Van Wies, and Cow Island dikes, (the latter raised one foot,) to the Cedar Hill and Castleton dikes, and the dikes at Coeymans.

5. Willows were planted along Cow Island dike, at Staats dike, on the shoal northeast of Coeymans, and on the lower end of Schermerhorn Island.

Amount available July 1, 1875	$39,770 63
Amount expended during fiscal year ending June 30, 1876	34,255 54
Amount available July 1, 1876	5,515 09
Amount appropriated by act approved August 14, 1876	50,000 00
Amount (estimated) required for completion of existing project	164,116 47
Amount that can be profitably expended in fiscal year ending June 30, 1878.	66,000 00

(See Appendix D 1.)

2. *Removing obstructions in East River and Hell Gate, New York.—Hallet's Point.*—During the year the work has been confined to drilling holes in the roof and piers preparatory to the final blast. The roof of the mine contains 5,375 holes, each 3 inches in diameter, and averaging 9 feet in length; the piers contain 1,385 holes, of which 288 are 2 inches in diameter, the balance being 3 inches in diameter, and averaging 9 feet in length.

Flood Rock.—During the year two shafts, 65 feet apart, have been partially completed, the larger one being 10 by 20 feet in plan and 51 feet deep, the bottom being 41 feet below mean low water; the smaller shaft is about 12 feet square in plan and is 32 feet deep. The aggregate length of tunnels driven from the two shafts is 229 feet.

Number of holes drilled	13,826
Number of drills sharpened	4,691
Loss of steel by abrasion and dressing, pounds	359
Cost of drilling per linear foot of holes, cents	.42
Cubic yards of rock removed	1,462

Operations of Steam-drilling Scow.—Coenties Reef.—The removal of this reef was completed August 27, 1875, a depth of 25½ feet at mean low water having been obtained.

Cubic yards of rock removed	1,375
Number of drill-hole blasts made	40

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Number of surface-blasts made	5
Number of holes drilled	271
Number of feet drilled	2,017.93
Nitro-glycerine used, pounds	13,840½
Dynamite, pounds	88
Cost per cubic yard	$33.89

Diamond Reef.—The scow was engaged on this reef from October 8, 1875, to November 24, 1875, and resulted in the removal of a part of the reef to a depth of 26 feet at mean low water. Work had to be suspended for want of funds.

Cubic yards of rock removed	971.7
Number of drill-hole blasts made	19
Number of surface-blasts made	4
Number of holes drilled	131
Number of feet drilled	1,318½
Nitro-glycerine, pounds	8,581
Cost per cubic yard	$24 53

Amount available July 1, 1875	$252,718 46
Amount expended during fiscal year ending June 30, 1876	198,577 00
Amount available July 1, 1876	54,141 46
Amount appropriated by act approved August 14, 1876	250,000 00
Amount (estimated) required for completion of existing project	3,213,278 55
Amount that can be profitably expended in fiscal year ending June 30, 1878	600,000 00

(See Appendix D 2.)

3. *Dredging in Hudson River, opposite Jersey City.*—Under contract, 105,924 cubic yards of soft material were dredged from the river in the vicinity of the Cunard Docks and Jersey Ferry slips, and by hired labor 57,715 cubic yards, making a total of 163,639 cubic yards of material removed.

Amount available July 1, 1875	$23,756 63
Amount expended during fiscal year ending June 30, 1876	23,655 58
Amount available July 1, 1876, including $93 due on contracts	101 05
Amount (estimated) required for completion of existing project	76,807 20
Amount that can be profitably expended in fiscal year ending June 30, 1878.	76,800 00

(See Appendix D 3.)

4. *Improvement of Harlem River, New York.*—Operations were conducted with the steam-drilling scow, and resulted in the removal of the reef off East 125th street, from a depth of 9 feet to that of 14½ feet at mean low water, in 36 working days, from August 27, 1875, to October 7, 1875.

Cubic yards of rock removed	1,003
Number of drill-hole blasts made	13
Number of surface-blasts made	2
Number of holes drilled	102
Number of feet drilled	931.16
Nitro-glycerine used, pounds	5,774
Cost per cubic yard	$16 53

Amount available July 1, 1875	$17,673 26
Amount expended during fiscal year ending June 30, 1876	17,673 26
Amount (estimated) required for completion of existing project	146,875 56
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

(See Appendix D 4.)

5. *Improvement of Passaic River, New Jersey.—Belleville Bar.*—The channel cut through this bar has been swept over and some loose stones taken up; a projection of solid rock was also found, which required a surface-blast to break it up for removal.

Rutherford Park Bar.—The small drilling-scow was employed in drilling and blasting projecting masses of bed-rock for the purpose of straightening the cut through this bar; the broken rock was removed by means of a small grapple rigged to the drilling-scow.

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Holsmans Bar.—By hired labor a cut has been made through this bar 1,300 feet long, 50 feet wide at the top, and 40 feet wide on the bottom, giving a depth of 6 feet at low water.

A cut of 300 feet was also made through a small bar above Holsmans.

Amount available July 1, 1875	$17,234 10
Amount expended during fiscal year ending June 30, 1876	16,770 63
Amount available July 1, 1876	463 47
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	24,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	24,000 00

(See Appendix D 5.)

6. *Improvement of East Chester Creek, New York.*—No work has been done during the year, the State commissioners not having as yet succeeded in obtaining a title to all the several parcels of land required, one parcel yet remaining unsettled. The prospect is, at present, that this will be adjusted at an early date.

Amount available July 1, 1875	$32,519 79
Amount expended during fiscal year ending June 30, 1876	1,698 97
Amount available July 1, 1876	30,820 82
Amount (estimated) required for completion of existing project	136,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	

(See Appendix D 6.)

7. *Improvement of Port Chester Harbor, New York.*—No appropriation having been made for this work, no operations were conducted during the year.

Amount available July 1, 1875	$2,236 70
Amount available July 1, 1876	2,236 70
Amount (estimated) required for completion of existing project	84,632 00
Amount that can be profitably expended in fiscal year ending June 30, 1878, to complete the removal of sunken rocks	60,000 00

(See Appendix D 7.)

8. *Improvement of Rondout Harbor, New York.*—No appropriation having been made for this work, no operations were conducted. Some repairs were made to the pile dike and to the crib sunk on the end of the dike, an allotment of $1,000 having been made for that purpose from the appropriations for repairs of harbors on the Atlantic coast and contingencies of rivers and harbors, &c.

Amount available July 1, 1875	$9 31
Amount available July 1, 1876	9 31
Amount appropriated by act approved August 14, 1876	30,000 00
Amount (estimated) required for completion of existing project	112,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	74,000 00

(See Appendix D 8.)

9. *Improvement of the channel between Staten Island and New Jersey.*—The board of engineers appointed to examine and report a plan for the improvement of this channel made their report December 15, 1875, and submitted the following estimate:

Dredging, 230,000 cubic yards, at 16 cents	$36,800 00
Contingencies, 10 per cent	3,680 00
	40,480 00

Amount available July 1, 1875	254 24
Amount expended during fiscal year ending June 30, 1876	24 50
Amount available July 1, 1876	229 74
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	30,480 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	10,000 00

(See Appendix D 9.)

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10. *Improvement of the harbor at Plattsburgh, New York.*—During the year no operations have been conducted.

Amount available July 1, 1875	$5,473 92
Amount expended during fiscal year ending June 30, 1876	532 40
Amount available July 1, 1876	4,941 52

11. *Improvement of the harbor at Burlington, Vermont.*—During the year the superstructure of the extension of 145 feet of breakwater has been completed and the crib-work for an extension of 160 feet in a northerly direction has been sunk and filled with stone.

In the month of February, 1876, the southern end of the breakwater was very much injured by a succession of ice-floes coming in contact with it during the prevalence of a terrific northwesterly storm.

Amount available July 1, 1875	$33,038 33
Amount expended during fiscal year ending June 30, 1876	25,447 62
Amount available July 1, 1876, including $6,430 due on contracts	7,590 71
Amount appropriated by act approved August 14, 1876	20,000 00
Amount (estimated) required for completion of existing project	295,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

(See Appendix D 10.)

12. *Improvement of the harbor at Swanton, Vermont.*—During the year the superstructure of the extension of 70 feet of breakwater has been completed, and the damage done to the crib by the ice in April, 1875, has been repaired.

The crib-work for an extension of 69 feet has been sunk and filled with stone.

Amount available July 1, 1875	$12,843 91
Amount expended during fiscal year ending June 30, 1876	9,432 06
Amount available July 1, 1876, including $2,470.20 due on contracts	3,411 85
Amount appropriated by act approved August 14, 1876	2,000 00
Amount (estimated) required for completion of existing project	237,160 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

(See Appendix D 11.)

13. *Improvement of Otter Creek, Vermont.*—During the year the creek was dredged by contract, and 13,000 cubic yards of silt, stone, clay, gravel, and sunken logs removed.

The improvements thus far made enable vessels to ascend with their cargoes to within 150 feet of the "Horse Nail factory wharf."

Amount available July 1, 1875	$5,086 47
Amount expended during fiscal year ending June 30, 1876	5,022 78
Amount available July 1, 1876	63 69
Amount (estimated) required for completion of existing project	43,146 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	43,000 00

(See Appendix D 12.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of March 3, 1875, Lieutenant-Colonel Newton was charged with and has completed the following:

1. *Examination at Rouse's Point, Lake Champlain, New York.*—(See Appendix D 13.)

2. *Survey at Port Henry, Lake Champlain, New York.*—(See Appendix D 14.)

3. *Survey of Echo Harbor, New Rochelle, New York.*—(See Appendix D 15.)

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CONSTRUCTION OF PIER AT LEWES, DEL.—HARBOR IMPROVEMENTS ON DELAWARE RIVER AND BAY—IMPROVEMENT OF THE NAVIGATION OF DELAWARE AND SCHUYLKILL RIVERS; OF BROADKILN RIVER, DELAWARE; AND OF SHREWSBURY RIVER AND COHANSEY CREEK, NEW JERSEY—DELAWARE BREAKWATER HARBOR.

Officer in charge, Lieut. Col. J. D. Kurtz, Corps, of Engineers, with Capt. M. R. Brown, Corps of Engineers, under his orders to October 28, 1875.

1. *Construction of pier near Lewes, Delaware.*—During the fiscal year work on the pier has been advanced as follows: The delivery of the 35 pile-shafts, and their corresponding screws, caps, braces, and other parts manufactured under the contract of April 24, 1875, was commenced early in July, and the last shipment was made in October.

Thirty piles have been inserted, the first row of 5 piles, 1,428 feet, and the last 1,533 feet from the abutment zero, increasing the length of the substructure 126 feet, and the depth of water from 19 to 21 feet at low-water.

The superstructure was lengthened from 1,302 feet to 1,428 feet, or 126 feet.

The near exhaustion of the appropriation in October required a suspension of operations, leaving on hand iron material for 2 more bays, or 42 linear feet of substructure.

During the fiscal year ending June 30, 1877, it is proposed, should an appropriation be made for the purpose, to place in position the material on hand, to contract for other material for 4 bays, and to place it in the work.

Amount available July 1, 1875	$39,293 90
Amount expended during fiscal year ending June 30, 1876	39,218 47
Amount available July 1, 1876	75 43
Amount appropriated by act approved August 14, 1876	30,000 00
Amount (estimated) required for completion of existing project	70,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	70,000 00

(See Appendix E 1.)

2. *Ice-harbor at New Castle, Delaware.*—A new stone ice-pier has been completed during the year, and the outer end of the coal-wharf, below the harbor, has been removed for a distance of 108 feet from the head. The present fiscal year it is proposed to complete the removal of this wharf to the line established by the town commissioners.

Next year it is proposed to construct another ice-pier at this harbor, and to dredge out the accumulated sediment, for which purpose an appropriation of $28,500 is asked.

Amount available July 1, 1875	$34,043 70
Amount expended during fiscal year ending June 30, 1876	30,949 30
Amount available July 1, 1876	3,094 40
Amount appropriated by act approved August 14, 1876	12,000 00
Amount (estimated) required for completion of existing project	28,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	28,500 00

(See Appendix E 2.)

3. *Wilmington Harbor, Delaware.*—During the past year work has been in progress along the channel of the river near the entrance, just above and below 3rd street, and above Market street. The result has been to increase the width of the channel at the locality near the mouth to 300 feet, and above 3rd and Market streets to 150 feet, and in each case to afford 12 feet depth of water at low tide. At the rock excavation the depth has been made 13 feet.

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It is proposed the present season to remove by dredging, between the mouth of the Brandywine and just above Market street, about 21,000 cubic yards of mud, and just below 3rd street 210 cubic yards of rock, which will complete the improvement at that point.

Next season it is proposed to remove, by dredging, between the mouth of the river and the mouth of the Brandywine, about 70,000 cubic yards of mud. This will require an appropriation of $20,000.

Amount available July 1, 1875	$10,129 34
Amount expended during fiscal year ending June 30, 1876	10,009 05
Amount available July 1, 1876	120 29
Amount appropriated by act approved August 14, 1876	16,000 00
Amount (estimated) required for completion of existing project	20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	20,000 00

(See Appendix E 3.)

4. *Marcus Hook Harbor, Pennsylvania.*—During the year important repairs have been made to the lower outer ice-pier. The damage sustained by the pier from collision of an iron-steamship was more serious than was apparent upon the first examination, and the cost for repairs in excess of the original estimate, which was $1,650, the cost being finally $2,509.

It is proposed to examine the river-bottom around the bases of the four piers with a view of protecting them with a riprap wall, should their condition require it.

Amount available July 1, 1875	$9,497 53
Amount expended during fiscal year ending June 30, 1876	2,795 62
Amount available July 1, 1876	6,701 91

(See Appendix E 4.)

5. *Ice Harbor at Chester, Pennsylvania.*—Since the year 1873, when the connecting bridges to the upper line of piers were renewed, no work has been done at this harbor. A portion of the upper timber-work, at upper and lower piers and wharves, and the bridge to the lower pier, require renewing; also, minor repairs are needed to the connecting bridges to upper piers, and to the earth and stone causeway leading from lower pier back to the fast land.

Should an appropriation be made available, it is proposed to execute the repairs required at this harbor during the present season.

Amount appropriated by act approved August 14, 1876	$2,600
Amount (estimated) required for completion of existing project	3,400
Amount that can be profitably expended in fiscal year ending June 30, 1878	3,400

(See Appendix E 5.)

6. *Improvement of Schuylkill River, Pennsylvania.*—During the past year, dredging has been done at the mouth; near Girard Point; above Penrose Ferry bridge, and near Gibson's Point. In all cases the depth of water attained is 20 feet at low tide. Except for a short strip just above Penrose, an uninterrupted channel now exists from the mouth to Gibson's, with not less than 150 feet in width and 20 feet depth at low water.

It is proposed during the present season to remove a small amount of deposit from the mouth of the river; 3,000 cubic yards of gravel from the channel above Penrose Ferry bridge to complete the work there; 18,000 cubic yards of coarse material and 150 cubic yards of rock from the channel near Gibson's, and 8,000 cubic yards of material from the channel above Gibson's Point.

It is recommended to increase the width and depth of the channel at the mouth of the river, the former to 300 feet and the latter to 24 feet

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at an estimated cost of $75,000, in order to accommodate the great grain trade now conducted at the Girard Point elevator.

Next year it is proposed to remove about 140,000 cubic yards of mud between the mouth and Girard Point, to obtain ultimately 24 feet depth at low water, and 150 cubic yards of rock from the channel above Gibson's.

Amount available July 1, 1875	$19,759 34
Amount expended during fiscal year ending June 30, 1876	19,659 49
Amount available July 1, 1876	99 85
Amount appropriated by act approved August 14, 1876	20,000 00
Amount (estimated) required for completion of existing project	209,700 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	60,000 00

(See Appendix E 6.)

7. *Improvement of Delaware River at Fort Mifflin Bar.*—During the fiscal year ending June 30, 1876, 125,016 cubic yards of material have been removed, affording 22 feet depth of water at low tide.

Operations have been in progress under two contracts, and under appropriations made by acts dated respectively June 23, 1874, and March 3, 1875. The work ceased April 5, 1876, under the latter appropriation, and was then continued under the appropriation for improving the Delaware River between Petty's Island and its mouth.

Amount available July 1, 1875	$39,959 89
Amount expended during fiscal year ending June 30, 1876	39,959 89

(See Appendix E 7.)

8. *Improvement of Delaware River between Petty's Island and its mouth.*—During the fiscal year ending June 30, 1876, operations have been applied under this appropriation to improvements at Fort Mifflin Bar, Bulkhead shoals, and the channel below Reedy Island.

At Fort Mifflin Bar, 96,221 cubic yards of material were removed, the extent of the excavation being about 2,500 feet in length and 200 feet in width, the new channel being now about 1,200 feet wide, with about 22 feet depth at ordinary low tide.

At Bulkhead Shoals about 98,000 cubic yards of material were removed from a shoal at the "Bend." A cut 2,800 feet in length and 250 feet in width was made, with a depth of water of 21 feet at low tide.

Below Reedy Island a sunken wreck has been removed from the main ship-channel.

It is proposed during the present season to remove accumulations of mud that have taken place in Fort Mifflin Bar cut and at its southern outlet, to continue the improvement at Bulkhead Shoals, and remove existing shoal points on the northern and western side of the channel.

Next year it is proposed to continue the removal of shoal points along the easterly side of Bulkhead Channel, lower down the river.

Amount available July 1, 1875	$49,075 55
Amount expended during fiscal year ending June 30, 1876	49,075 55
Amount appropriated by act approved August 14, 1876	40,000 00
Amount (estimated) required for completion of existing project	235,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	100,000 00

(See Appendix E 8.)

9. *Improvement of Delaware River between Trenton and White Hill, New Jersey.*—The appropriation of $10,000, made by act of March 3, 1875, was expended in improving the channel around Periwig Island. A channel with a width of 125 feet and a depth of 6 feet at low-water was the result of the operations. If a further appropriation be made, it will

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be applied at the same locality, to remedy obstructions caused by freshets, and to widen the channel.

Amount available July 1, 1875	$10,000
Amount expended during fiscal year ending June 30, 1876	10,000
Amount (estimated) required for completion of existing project	30,000
Amount that can be profitably expended in fiscal year ending June 30, 1878	10,000

(See Appendix E 9.)

10. *Improvement of Broadkiln River, Delaware.*—The appropriation for this work was exhausted in 1874, since when no further appropriation has been made.

Amount (estimated) required for the completion of existing project	$60,447
Amount that can be profitably expended in fiscal year ending June 30, 1878	10,000

(See Appendix E 10.)

11. *Improvement of the north and south branches of Shrewsbury River, New Jersey.*—No appropriation was made for the last fiscal year.

A survey has been made at several places, and an estimate of $18,000 submitted for the improvement of the river at Upper and Lower Rocky Points.

Should it be the intention of Congress to continue this improvement, the sum of $13,000 will be required for the fiscal year ending June 30, 1878.

(See Appendix E 11.)

12. *Improvement of Cohansey Creek, New Jersey.*—No appropriation was made for the fiscal years ending June 30, 1875 and 1876, for continuing this improvement.

An appropriation is asked for widening and deepening the channel in accordance with the original project for the work.

Amount (estimated) required for completion of existing project	$20,000
Amount that can be profitably expended in fiscal year ending June 30, 1878	10,000

(See Appendix E 12.)

13. *Delaware Breakwater Harbor.*—Nothing has been done by the United States during the year to the works forming this harbor.

By permission of the War Department the Western Union Telegraph Company have occupied the old light-house building on the Breakwater as a telegraph station, and have erected a line of poles and wires along the structure, the connection with the shore-line being made by means of a cable laid across the channel to the beach opposite.

(See Appendix E 13.)

14. *Port Wardens' Line, Philadelphia, Pa.*—This question remains as last reported, nothing on the subject having been heard from the municipal authorities of Philadelphia.

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of March 3, 1875, Lieutenant Colonel Kurtz was charged with and has completed the following:

1. *Examination of the piers at Marcus Hook, Pa.*
2. *Examination of the lower pier at Chester, Pa.*

The results of these examinations were submitted with my last annual report.

3. *Survey of the north and south branches of Shrewsbury River, New Jersey.*

(See Appendix E 14.)

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IMPROVEMENT OF HARBORS AND RIVERS OF CHESAPEAKE BAY, MARYLAND; OF JAMES AND APPOMATTOX RIVERS, VIRGINIA, AND OF THE CAPE FEAR RIVER, NORTH CAROLINA.

Officer in charge, Maj. William P. Craighill, Corps of Engineers, who has had under his immediate orders Capt. C. B. Phillips, during the fiscal year, and Lieut. Edward Maguire, Corps of Engineers, until May 5, 1876.

1. *Improvement of Susquehanna River, near Havre de Grace, Maryland.*—No appropriation was made for this work during the fiscal year ending June 30, 1876, and no work of any kind has been done. No examination of it could be made, and its condition is therefore not known.

(See Appendix F 1.)

2. *Improvement of Northeast River, Maryland.*—No funds have been available for this locality during the fiscal year. No examination of it could be made, and its present condition is therefore not known.

(See Appendix F 2.)

3. *Improvement of Elk River, Maryland.*—After some difficulty and delay in finding a contractor for this locality, at a suitable price to attain any useful result with the available appropriation, $5,000, made March 3, 1875, a contractor commenced dredging September 30, 1875, and completed his engagement February 12, 1876. The number of cubic yards taken out was 15,565 at 25 cents per yard, including redeposit.

The work done was the excavation of a channel 40 feet wide at bottom with proper slopes, to a depth of 6 feet at mean low-water from the iron bridge at Elkton, to a point about a half mile below, and making a basin near the wharves of the town for turning steamboats.

The original estimate for this improvement, including Little Elk, was $36,000, and excluding it $30,000. The appropriations have been $5,000, June 23, 1874, $5,000 March 3, 1875, total, $10,000. If it be decided by Congress to complete this improvement as originally proposed, the remainder of the estimate should be appropriated in one sum.

Amount available July 1, 1875	$4,680 55
Amount expended during fiscal year ending June 30, 1876	4,680 55
Amount (estimated) required for completion of existing project	20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	20,000 00

(See Appendix F 3.)

4. *Improvement of Worton Harbor, Maryland.*—No funds have been available for this locality during the fiscal year. No examination of it could be made, and its present condition is therefore not known.

(See Appendix F 4.)

5. *Improvement of Queenstown Harbor, Maryland.*—No funds have been available for this locality during the fiscal year. No examination of it could be made, and its present condition is therefore not known.

(See Appendix F 5.)

6. *Improvement of Chester River at Kent Island Narrows, Maryland.*—The appropriations for this work have been, March 3, 1873, $15,000; June 23, 1874, $5,000; August 14, 1876, $5,000; but owing to causes of delay explained in previous reports, nothing was done in carrying out the project until May, 1875.

Operations ceased July 7, 1876, the available funds being exhausted. The portion of the work on the Easton Bay side was completed to a width of 80 feet in September, 1875.

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On the Chester River side the width had been for a considerable distance made 100 feet—the width originally designed—the remainder being not less than 75 feet wide. The causeway had been cut through in May, 1876, a bridge with draw-span of 60 feet, as required by law, having been previously built at the expense of the counties of Queen Anne and Talbot. Thus through the entire channel (except the causeway) a width of not less than 75 feet had been attained. A depth of 7 feet at ordinary low-water has been also attained through the entire length of the channel.

Three thousand dollars would fill out the estimate; but owing to the long but unavoidable delay and protraction of the operations which have occurred, and the attendant increase of expense, the sum of $5,000 will not more than complete the work estimated for. To keep the channel open when excavated, occasional repairs will be required. The cost will probably average $3,000 per annum.

Amount available July 1, 1875	$18,704 98
Amount expended during fiscal year ending June 30, 1876	13,330 83
Amount available July 1, 1876, including $1,282.73 due on contracts	5,374 15
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878, (see explanation above)	3,000 00

(See Appendix F 6.)

7. *Improvement of the entrance to the harbor of Baltimore, Maryland.*—The operations of the year have been confined to the Brewerton Channel. An addition of about 40 feet to its width has been made, and the turn has been rendered easier for long steamers at the angle where this channel joins the Fort McHenry Channel. Some shoaling was found to have taken place, as has been always expected and predicted, at the lower end of this channel, where it necessarily projects into and across the current of the Susquehanna below North Point. No place, however, was found with less than 23 feet at mean low-water.

The object of this work has been to make such a channel as will enable vessels drawing 22½ or 23 feet, to come to the city at any ordinary state of the tide. At high-water vessels of 24 feet can be brought up. This object has been attained, but the width of channel is the minimum. For the reasons stated by the officer in charge, an appropriation of $135,000 is strongly recommended.

Amount available July 1, 1875	$69,485 87
Amount expended during fiscal year ending June 30, 1876	68,691 19
Amount available July 1, 1876	794 68
Amount appropriated by act approved August 14, 1876	75,000 00
Amount (estimated) required for completion of existing project, (see report of last year)	160,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	135,000 00

(See Appendix F 7.)

8. *Improvement of Cambridge Harbor, Maryland.*—No funds have been available for this locality during the fiscal year. No examination of it could be made, and its present condition is therefore not known. (See Appendix F 8.)

9. *Improvement of the Wicomico River, near Salisbury, Maryland.*—The original plan of improvement was to dredge a channel 75 feet wide and 7 feet deep, at mean low-water, and deposit the material behind longitudinal dikes. The work dragged through a part of 1872, 1873, 1874, and a part of 1875, owing to insufficient appropriations, and other causes of delay. For a history of the progress up to June 30, 1875, see last annual report.

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The diking was completed, as far as funds allowed, July 16, 1875, the length of new diking being 1,636 feet.

The dredging was continued until January 7, 1876, when the funds were exhausted and the work suspended.

It had been expected to use the available means in making a channel 50 feet wide at bottom, and 5 feet deep at mean low-water, and in preparing a basin near the wharves for steamboats to turn in. This was accomplished, except for a short space, where a width of but 38 feet could be given, owing to lack of funds.

The appropriations have been, June 10, 1872, March 3, 1873, June 23, 1874, March 3, 1875, August 14, 1876; total $25,000. Should the original plan be carried out, an appropriation of $15,000 will still be required.

Amount available July 1, 1875	$11,669 22
Amount expended during fiscal year ending June 30, 1876	11,598 18
Amount available July 1, 1876	71 04
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project, (see last annual report)	20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	15,000 00

(See Appendix F 9.)

10. *Improvement of harbor of Crisfield, Maryland.*—The object of this improvement was to dredge a channel of about 12 feet depth at mean low-water across the bar near Somer's Cove light to the railroad-wharf and to make a basin for vessels at and near the town. The estimate was $37,317.50, all of which was appropriated in one sum March 3, 1875.

The work was soon placed under contract and commenced May 12, 1875. It was completed May, 1876, to the satisfaction, it is believed, of all concerned. It is to be remembered that repairs will in time be required for this artificial channel and harbor, but no appropriation is now needed or asked for.

Amount available July 1, 1875	$35,575 62
Amount expended during fiscal year ending June 30, 1876	35,555 84
Amount available July 1, 1876	19 78

(See Appendix F 10.)

11. *Improvement of James River, Virginia.*—The work of the United States on this improvement has been done partly by contract and partly by machinery belonging to the United States. Certain machinery belonging to the city of Richmond has also been hired and operated by the United States, the rental not exceeding the cost to the city of repairs.

The following statement shows the cubic yards removed:

New channel at Gillie's Creek Shoal: earth, 18,794 yards; rock, 196; side channels to Drury's Island dike: earth, 4,148; new channel at Goode's Rocks: earth, 1,600; rock, 949; enlargement of Dutch Gap cut-off: earth, 31,016. The city of Richmond has done a nearly equal quantity of work.

The United States has built dikes and wing-dams as follows: At upper end of Drury's Island, by contract, 1,326½ linear feet; at Richmond Bar, by hired force, 683 feet; and at Randolph Flats, 788 feet; total, 2,797½ feet.

The Dutch Gap cut-off is now 180 feet wide at surface of water and has a depth of about 15 feet at low-tide. It can be used by all classes of vessels coming to Richmond, but would be improved by a further enlargement. The condition of the river is otherwise better than it was

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a year ago. The new channel through Gillie's Creek Shoal permits vessels of 14 feet draught to leave the dock and proceed to sea. The shallow reach below Rockett's Reef has been deepened and widened, and the channel over Richmond Bar has been increased in width 100 feet.

A comparison of the condition of the river at present with what it was five years ago shows a very great actual improvement, and what has already been accomplished at the same time opens the way for a more rapid advance at moderate cost to a still higher state of usefulness to commerce.

Amount available July 1, 1875	$47,555 09
Amount expended during fiscal year ending June 30, 1876	47,450 50
Amount available July 1, 1876	104 59
Amount appropriated by act approved August 14, 1876	60,000 00
Amount (estimated) required for completion of existing project	293,808 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	140,000 00

(See Appendix F 11.)

12. *Improvement of Appomattox River, Virginia.*—The work of the year has been done with funds provided March 3, 1875. The spring freshets of 1875 having caused some filling in the channel in its unfinished condition, the first operation was that of removing these deposits, in order to facilitate navigation. The remainder of the appropriation has been devoted to widening the Puddledock channel to about 100 feet, an important step forward in the plan of permanent improvement. The total cost of the improvement has been rendered greater up to this time than necessary, owing to the impossibility of properly conducting such a work with inadequate means.

Amount available July 1, 1875	$39,058 03
Amount expended during fiscal year ending June 30, 1876	31,444 86
Amount available July 1, 1876, including $1,331.26 due on contracts	7,613 17
Amount appropriated by act approved August 14, 1876	30,000 00
Amount (estimated) required for completion of existing project, (see last annual report)	113,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	83,000 00

(See Appendix F 12.)

13. *Improvement of the Cape Fear River, North Carolina.*—The width of the new channel behind the Horseshoe Shoal has been increased from 100 to about 200 feet, and its depth from 9 to 12 feet at low-water. This work has been carried on simultaneously with laying an apron of timber, brush, and stone on the bottom in the opening between Federal Point and Zeke's Island, and has the same object, the diversion of water from New Inlet to the old mouth of the river, near Baldhead Point. Both operations have been successful. This apron has been made as high and the channel has been made as wide as the available funds permitted.

The suction-dredge Woodbury was worked on the Baldhead Bar until late in January, 1876, when the condition of her machinery became such that she was necessarily withdrawn. Funds could not be spared for her repair. She has, consequently, been idle nearly half the year.

Some obstructions have been removed which were placed in the river near Wilmington, during the late war, by the confederate authorities, and a few days' dredging was done at a shoal near Campbell's Island.

The depth aimed at in the year's operations has been about 12 feet at low-water, and very nearly this depth can be carried at ordinary low-water from Wilmington to the ocean, a marked improvement in the condition of the river.

Surveys of the greater part of the river from Wilmington down have been made.

It is very important for the security of work already done, and the

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attainment of the object of the whole, that operations should be vigorously continued, especially at the closure of New Inlet.

Amount available July 1, 1875	$211,287 43
Amount expended during fiscal year ending June 30, 1876	188,564 71
Amount available July 1, 1876, including $9,444.46 due on contracts	22,722 72
Amount appropriated by act approved August 14, 1876	132,500 00
Amount (estimated) required for completion of existing project, (see last annual report)	210,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	77,500 00

(See Appendix F 13.)

EXAMINATION OF THE AQUEDUCT BRIDGE OVER THE POTOMAC RIVER AT GEORGETOWN, D. C.

Major Craighill was detailed by the Secretary of War to report upon the condition of the *Aqueduct Bridge*, in pursuance of a resolution of the Senate of February 3, 1876. His report, dated March 8, 1876, may be found in Appendix F 14 to this report; also, in Senate Ex. Doc. No. 39, 44th Congress, 1st session.

IMPROVEMENT OF THE HARBORS OF WASHINGTON AND GEORGETOWN, DISTRICT OF COLUMBIA; OF OCCOQUAN, RAPPAHANNOCK, ELIZABETH, AND NANSEMOND RIVERS, AND OF ACCOTINK, AQUIA, AND NOMINI CREEKS, VIRGINIA; AND OF ROANOKE RIVER, NORTH CAROLINA.

Engineer in charge, S. T. Abert, United States Civil Engineer.

1. *Harbors at Washington and Georgetown, District of Columbia.*—This improvement has been continued by the removal of rocks in Georgetown Harbor. The work was advertised for contract in July, 1875, but the bids received were rejected, as it was found that the work, which was of a special character, could be done more cheaply by hired labor. The machinery and force employed on similar work on the James River, Virginia, were transferred to Georgetown, and active operations commenced in March, 1876. Three of the most dangerous rocks have been nearly removed, the amount of rock excavation being 336 cubic yards.

In my last annual report it was stated that in carrying out the plan of improvement recommended by the Board of Survey created by the act of March 3, 1872, the first operation of importance would be the removal of Easby's Point, the estimated cost of which is $550,000.

Apart from this there is an immediate necessity for an appropriation of $14,000, for dredging the Washington channel between the arsenal and the Long Bridge. This channel is the only access for steamboats and shipping to the city wharves, and is becoming shoaler each succeeding year.

Amount available July 1, 1875	$20,755 24
Amount expended during fiscal year ending June 30, 1876	11,313 37
Amount available July 1, 1876	9,441 87
Amount that can be profitably expended in fiscal year ending June 30, 1878.	14,000 00

(See Appendix G 1.)

2. *Accotink Creek, Virginia.*—No funds have been available for this improvement during the year, and no work has been done.

The amount required to complete the work according to the original estimate is $14,000.

(See Appendix G 2.)

3. *Occoquan River, Virginia.*—During the past year a channel 80 feet

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wide and 5½ feet deep at low-water has been excavated through the bar between the railroad bridge and Occoquan, the material being deposited below the bridge. It was found that the channel had filled in to such an extent as to require its re-excavation. The funds available were only sufficient for a portion of this work.

For the completion of the improvement by the construction of a dike $5,000 are asked, in addition to the $3,000 required to complete the dredging.

Amount available July 1, 1875	$5,493 92
Amount expended during fiscal year ending June 30, 1876	5,071 91
Amount available July 1, 1876	422 01
Amount (estimated) required for completion of existing project	8,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	8,000 00

(See Appendix G 3.)

4. *Aquia Creek, Virginia.*—The channel commenced in 1874—between the railroad bridge and the narrows—has been completed to a width of 40 feet and a depth of 4 feet at low-water. The small sums appropriated for this work render it necessary to increase the total estimate to $20,000, and as the total amount of appropriation to this date is $5,500, there will be required for completion $14,500.

Amount available July 1, 1875	$2,003 71
Amount expended during fiscal year ending June 30, 1876	2,003 71
Amount (estimated) required for completion of existing project	14,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	14,500 00

(See Appendix G 4.)

5. *Nomini Creek, Virginia.*—The dredging operations of last year were not completed, owing to delays and interruptions from breakage of machinery. The channel was widened near White and Hickory Points, and oak piles have been driven along the entire line, so that it may be safely navigated. Since the suspension of dredging small steamers have been regularly plying between the creek and Washington.

Amount available July 1, 1875	$4,997 67
Amount expended during fiscal year ending June 30, 1876	3,144 44
Amount available July 1, 1876, including $180.48 due on contract	1,853 23
Amount (estimated) required for completion of existing project	6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	6,000 00

(See Appendix G 5.)

6. *Rappahannock River, Virginia.*—The channel along the wharves in progress at the date of the last report was completed in July, 1875. The channel between the wharves and Deep Run, 50 feet wide and 9 feet deep at low-water, was completed, as far as the funds would allow, in May, 1876. It is found that these channels, as was anticipated, fill in rapidly from the effect of freshets. An annual appropriation of $7,500 will therefore be required to preserve a depth of 9 feet upon this portion of the river. Castle Ferry Bar, 9 miles below Fredericksburg, does not at present need improvement.

Amount available July 1, 1875	$13,437 57
Amount expended during fiscal year ending June 30, 1876	13,036 82
Amount available July 1, 1876	400 75
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	34,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	34,000 00

(See Appendix G 6.)

7. *Elizabeth River, Virginia.*—The work of dredging was commenced by contract July 27, 1875. A channel 60 feet wide and 7½ feet deep at low-water has been dredged between the lock of the Albemarle and

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Chesapeake Canal and a point near Park's Gap. This was completed October 6, 1875. The material excavated was deposited on the marshes and at points where it would not interfere with navigation. For the completion of the present project, $3,500 will be required.

Amount available July 1, 1875	$4,726 40
Amount expended during fiscal year ending June 30, 1876	4,608 38
Amount available July 1, 1876	118 02
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	3,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	3,500 00

(See Appendix G 7.)

8. *Nansemond River, Virginia.*—The appropriation for the work of the past year was expended in dredging a channel 60 feet wide and 7½ feet deep at low-water through the bar at Suffolk, and in the removal of a wreck at this point. The work was commenced October 20, 1875, and completed January 5, 1876. The old dike near Western Branch Bar is in bad condition and should be repaired. The $2,000 required to complete the work according to the estimate of last year should be employed for this object.

Amount available July 1, 1875	$6,921 52
Amount expended during fiscal year ending June 30, 1876	6,833 93
Amount available July 1, 1876	87 59
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	2,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	2,000 00

(See Appendix G 8.)

9. *Roanoke River, North Carolina.*—Continued freshets in this river for almost the entire year have prevented the completion of the dike at Indian Highland Bar; 986 linear feet have, however, been built, and it is thought that the work may be finished during the present stage of low water. The gauge observations at Weldon and Hamilton have been continued, and the record of observations from February 1, 1875, to June 30, 1876, is submitted.

If Congress should determine to continue this improvement, $45,000 should be appropriated for the next year. If, however, it is the opinion that operations should be suspended, $3,000 will still be required for the removal of snags.

Amount available July 1, 1875	$10,586 12
Amount expended during fiscal year ending June 30, 1876	5,303 49
Amount available July 1, 1876, including $236.88 due on contracts	5,282 63
Amount (estimated) required for completion of existing project	222,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	45,000 00

(See Appendix G 9.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of March 3, 1875, Mr. S. T. Abert was charged with and has completed the following, viz:

1. *Examination of the East Branch of Potomac River, from the navy-yard to Bladensburgh, Md.* (See Appendix G 10.)

2. *Examination of the harbor at Edenton, N. C.* (See Appendix G 11.)

3. *Examination of Pasquotank River, from Albemarle Sound to Elizabeth City, N. C.* (See Appendix G 12.)

4. *Examination of Perquimans River, from its mouth to the town of Hertford, N. C.* (See Appendix G 13.)

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5. *Examination of Pamlico River, from its mouth to the town of Washington, N. C.* (See Appendix G 14.)

6. *Examination of Neuse River, from its mouth to Goldsborough, N. C.* (See Appendix G 15.)

7. *Examination of Catawba River, from South Carolina line to Old Fort, North Carolina.* (See Appendix G 16.)

The results of the above examinations were transmitted to Congress January 21, 1876, and printed in H. R. Ex. Doc. No. 94, Forty-Fourth Congress, first session.

8. *Survey of a line to connect the waters of the Neuse and Cape Fear Rivers, in North Carolina, and of a line to connect the waters of Norfolk Harbor, in Virginia, with the waters of Cape Fear River, at or near Wilmington, N. C.*—The report made to this Office of the results of the survey was transmitted to Congress March 6, 1876, and printed in Senate Ex. Doc. No. 35, 44th Congress, 1st session. (See also Appendix G 17.)

IMPROVEMENT OF THE RIVERS AND HARBORS ON THE COAST OF SOUTH CAROLINA, GEORGIA, AND THE ATLANTIC COAST OF FLORIDA.

Officer in charge, Lieut. Col. Q. A. Gillmore, Corps of Engineers, having under his immediate orders Capt. James C. Post, Corps of Engineers.

1. *Improvement of Charleston Harbor, South Carolina.*—During the past fiscal year the work of removing the outer end of "Bowman's" jetty has been completed to a low-water depth of 16½ feet over that portion of the jetty outside of the point selected for a new pier-head. The total number of cubic yards of stone removed was 2,667, of which 663 cubic yards were piled on the shore end of the jetty and 2,004 cubic yards deposited in deep water. A gap or depression in the shore end of the jetty was permanently closed.

The United States dredging-steamer Henry Burden removed 9,632 cubic yards of sand from the channel, making it 200 feet wide and 12½ feet deep. Since the completion of the removal of the outer end of the jetty, portions of the channel that were before deep have shoaled considerably. It is proposed to remove these shoals by dredging, $10,000 having been asked for this purpose in my last annual report.

No appropriation is now recommended for continuing the work beyond the amount specified above.

Amount available July 1, 1875	$24,991 70
Amount expended during fiscal year ending June 30, 1876	23,982 90
Amount available July 1, 1876, including $1,000 due on contracts	1,008 80
Amount appropriated by act approved August 14, 1876	10,000 00

(See Appendix H 1.)

2. *Improvement of Savannah River and Harbor, Georgia.*—During the last fiscal year the operations have consisted in dredging, and in the partial construction of a temporary dam at the Cross Tides, in order to increase the volume of ebb flow in Front River along the wharves of the city of Savannah. The quantity of material dredged amounted to 225,542 cubic yards. Of this amount 18,349 cubic yards were taken from the shoal northeast of Fort Pulaski by the United States dredging-steamer Henry Burden, giving an increase of width to the channel previously established through that shoal. There seems to be a slight indication of shoaling in this channel at its upper end, near the first or inner buoy, but it is doubtful if it will be permanent. At the new chan-

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nel through the shoal known at "The Wrecks," at the lower end of Fig Island, 189,348 cubic yards have been removed, 133,119 by contract and 56,229 cubic yards by the United States dredging-steamer Henry Burden. This channel is now 100 feet wide and 10 feet deep at mean low-water, and shows evidence of constant and continued enlargement by the scour of the current. At the shoal known as Garden Bank, opposite the city, 7,995 cubic yards have been removed, and the channel is now 140 feet wide and 14 feet deep. Between King's and Hutchinson's Islands 9,850 cubic yards were removed, and a channel 40 feet wide and 6 feet deep was made to facilitate the flow into and through Front River.

The temporary dam at the Cross Tides was a little more than half completed when work was suspended by a temporary injunction granted by the United States Supreme Court, upon the complaint of citizens of the State of South Carolina.

During the present fiscal year it is proposed, in case funds are supplied by Congress—

A. To complete the temporary dam commenced at Cross Tides, should the injunction be removed.

B. To increase the dimensions, by dredging, of new channel at "The Wrecks" and remove such cribs and wrecks as may be found obstructing this channel.

C. To increase by dredging the depth of the channel over the shoals abreast of Elba Island and opposite Long Island.

D. To commence the removal of Kinsey's Point, opposite the city of Savannah, provided a satisfactory arrangement of the question of damage to private property can be made.

An additional appropriation of $200,000 is requested.

The report of the board of engineer officers constituted June 5, 1875, to take into consideration and report upon the general subject of the improvement of Savannah River and Harbor, will be found in Appendix H 3.

Amount available July 1, 1875	$78,303 82
Amount expended during fiscal year ending June 30, 1876	74,532 01
Amount available July 1, 1876, including $885 due on contracts	3,771 81
Amount appropriated by act approved August 14, 1876	62,000 00
Amount (estimated) required for completion of existing project	361,320 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	200,000 00

(See Appendixes H 2, H 3, and H 4.)

3. *Improvement of inside passage between the Saint John's River and Fernandina, Florida.*—The act of Congress approved June 23, 1874, appropriated $10,000 "for continuing the improvement at the mouth of the Saint John's River, Florida, or may be used for dredging out the inside passage between Saint John's River and Nassau Inlet."

No operations were carried on during the last fiscal year for the improvement of Saint John's River.

The same act provided for a survey of the inside passage between Fernandina and Saint John's River. This survey was made, and a report from the officer in charge, suggesting certain improvements, with estimates, was submitted with my last annual report.

After deducting the cost of the survey, the sum of $7,372.40 remained, which has been expended in obtaining a channel of 40 feet in width and 4 feet deep at mean low-water through the shoals which obstructed this passage. In all, 28,973 cubic yards of material have been removed.

It is recommended that $50,000 be appropriated for the fiscal year

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ending June 30, 1878, to be expended in the improvement of the passage.

Amount available July 1, 1875	$7,372 40
Amount expended during fiscal year ending June 30, 1876	7,372 40
Amount (estimated) required for completion of existing project, $160,000 to	370,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	50,000 00

(See Appendix H 5.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

In reply to a resolution of the Senate of December 15, 1875, requesting the views of the Secretary of War as to the importance and practicability of *improving the channel of the entrance to Cumberland Sound*, with estimates of the probable cost of the construction, a report from Lieutenant-Colonel Gillmore, to whom the subject of the resolution was referred, was transmitted to the Senate at its last session, and printed as Senate Ex. Doc. No. 60, 44th Congress, 1st session. (See also Appendix H 6.)

The resolution of the Senate of March 16, 1876, requesting information as to the importance and practicability of *deepening the inside passage between Cumberland Sound and Saint Simon's Sound, Georgia*, with estimate of the probable cost of such improvement, was also referred to Lieutenant-Colonel Gillmore for report theron. His reply was transmitted to the Senate, and printed in Senate Ex. Doc. No. 59. (See Appendix H 7.)

And also a resolution of the Senate of April 18, 1876, requesting information as to the importance of the *harbor of Brunswick, Georgia*, and the necessity for its improvement. Lieutenant-Colonel Gillmore's report upon the subject of this resolution was transmitted to the Senate, and printed in Senate Ex. Doc. No. 63. (See Appendix H 8.)

GULF OF MEXICO.

IMPROVEMENT OF THE HARBORS OF MOBILE, ALABAMA, AND CEDAR KEYS, FLORIDA—IMPROVEMENT OF THE NAVIGATION OF CHOCTAWHATCHEE, APALACHICOLA, CHATTAHOOCHEE, AND FLINT RIVERS.

Officer in charge, Capt. A. N. Damrell, Corps of Engineers.

1. *Improvement of harbor at Mobile, Alabama.*—This improvement has been continued in accordance with the original plan.

The channel through Dog River Bar was completed during the year to its proposed width of 200 feet, with a depth of 13 feet at mean low-tide.

The work of widening the cut through Choctaw Bar has been delayed by heavy freshets in the river, but, it is expected, will be completed this season.

The funds available July 1, 1876, for this improvement are deemed sufficient for its completion, and no further appropriation is asked.

Amount available July 1, 1875	$71,437 39
Amount expended during fiscal year ending June 30, 1876	55,171 56
Amount available July 1, 1876	16,265 83

(See Appendix I 1.)

2. *Improvement of harbor of Cedar Keys, Florida.*—The appropriation of $15,000 of March 3, 1875, was expended during the last fiscal year in completing the dredging of a channel through the outer bar, 100 feet

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wide and 12 feet deep. The entire cut has been completed, and appears to have retained its depth to the present time.

It is proposed to apply any appropriations that may be made for the next fiscal year to widening the cut to 200 feet; to widening and deepening the channel inside Sea Horse Key, and widening and deepening the channel at the bend between Depot Key and Harbor or Grassy Key.

Appropriation asked by the officer in charge for the fiscal year ending June 30, 1878, $50,000.

Amount available July 1, 1875	$15,343 62
Amount expended during fiscal year ending June 30, 1876	15,338 67
Amount available July 1, 1876	4 95
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	101,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

(See Appendix I 2.)

3. *Improvement of Choctawhatchee River, Alabama and Florida.*—At the beginning of the fiscal year the work of improving this river was carried on under an unexpended balance of the appropriation of $5,000 of March 3, 1875, and was continued until September, 15, 1875, when, for want of further funds, operations had to be suspended. The work was mainly confined to the removal of snags, stumps, and overhanging trees, a large number of which were pulled, cut, and removed from the river.

A channel about 3 feet deep at low-water has been attained from the mouth of the river to Buzzard Bar, about 15 miles below Geneva, at which point the work had to be suspended. A wagon-road around this bar was, however, previously cut through the woods, to facilitate the transfer of freight at that point.

The improvement of Buzzard Bar, the dredging of loose rocks and gravel from some of the upper shoals and bars, the removal of some steamboat wrecks, and the snagging and clearing of 15 miles of the river, still remain to be done before light-draught boats can ascend to Geneva during low-water.

It is proposed to resume work on this river as soon as further appropriation is available.

An appropriation of $20,000 is asked by the officer in charge for the fiscal year ending June 30, 1878.

Amount available July 1, 1875	$3,297 30
Amount expended during fiscal year ending June 30, 1876	3,012 37
Amount available July 1, 1876	284 93
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	19,332 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	20,000 00

(See Appendix I 3.)

4. *Improvement of Apalachicola River, Florida.*—An appropriation of $10,000 for the improvement of this river was made by the act of June 23, 1874.

At the close of the previous fiscal year a snag-boat was engaged on the improvement of Moccasin Slough, which had been partly accomplished during that year, and after continuing the work through the months of July and August, 1875, during which time 108 snags and sunken logs were pulled out, over 100 overhanging trees cut and removed, and 1,831 cubic yards of earth excavated, to straighten the channel at the junction of the river with the slough, the snag-boat was moved to the Chattahoochee River, and work on the Apalachicola suspended; a navigable channel for boats drawing 5 feet having been

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attained from its mouth to the junction of Chattahoochee and Flint Rivers.

During the last freshet a large raft of logs lodged near the junction of Moccasin Slough and Styx River, seriously obstructing navigation. In the month of June, 1876, this raft was removed, and at the close of this year the river is again in fair navigable condition. A considerable amount of work, however, remains to be done in straightening the channel through Moccasin Slough and Styx River, to prevent the lodging of rafts and logs in future in the short bends still existing.

It is contemplated to continue the improvement of this river during next year by straightening its channel through Moccasin Slough and Styx River.

The unexpended balance of former appropriations, with the amount asked for next fiscal year, are deemed sufficient to complete the work.

Amount available July 1, 1875	$13,225 61
Amount expended during fiscal year ending June 30, 1876	4,670 11
Amount available July 1, 1876	8,550 50
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	10,000 00

(See Appendix I 4.)

5. *Improvement of Chattahoochee and Flint Rivers, Georgia.*—Work was commenced on the improvement of these rivers in the latter part of August, 1875, and continued till the 18th of January, 1876, at which time a rise compelled a cessation of operations.

Work was resumed again in May, 1876, and is in progress at the present time. The work consisted in the removal of snags and overhanging trees on both rivers and at the Wolfox Bar, on the Chattahoochee River, the construction of a breakwater or stone protection on the Georgia side, 380 feet long, the extension of the jetty built last year 235 feet inshore, and the building of a new jetty below, 200 feet long.

Both rivers are now in a tolerably navigable condition for the boats now running to Bainbridge, on the Flint, and Columbus, on the Chattahoochee.

Repairs were also made during the year to the snag-boat, and two flat-boats were constructed for blasting on the rock-shoals.

It is proposed to continue the work during the next fiscal year on the bars below Eufaula, on the Chattahoochee, and Bainbridge, on the Flint.

Appropriation asked by the officer in charge for the fiscal year ending June 30, 1878, $50,000.

Amount available July 1, 1875	$36,582 62
Amount expended during fiscal year ending June 30, 1876	8,979 56
Amount available July 1, 1876	27,603 06
Amount appropriated by act approved August 14, 1876	20,000 00
Amount (estimated) required for completion of existing project	260,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878..	50,000 00

(See Appendix I 5.)

6. *Improvement of the Black Warrior and Tombigbee Rivers, Alabama.*—Operations for the improvement of these rivers were commenced at Tuscaloosa, Ala., in July, 1875, under the appropriation of $25,000 of March 3, 1875, and continued down the Black Warrior River until the 26th of November, when the usual high water from the winter rains compelled a suspension.

Twenty-one bars were improved by the construction of 4,533 feet of jetties, 791 feet of shore-protection, 1,298 feet of dams, and the removal of 361 cubic yards of rock, 4,708 yards of gravel, and 417 snags.

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Future appropriations will be applied to a continuation of the work already commenced.

Appropriation asked by the officer in charge for the fiscal year ending June 30, 1878, $100,000.

Amount available July 1, 1875	$25,000 00
Amount expended during fiscal year ending June 30, 1876	19,881 92
Amount available July 1, 1876	5,118 08
Amount appropriated by act approved August 14, 1876	15,000 00
Amount (estimated) required for completion of existing project	132,603 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	100,000 00

(See Appendix I 6.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENTS.

To comply with the provisions of the river and harbor act of March 3, 1875, Captain Damrell was charged with and completed an examination and survey of the *Alabama River from Wetumpka to its mouth.* For his report thereon see Appendix I 7.

WATER-COMMUNICATION BETWEEN THE MISSISSIPPI RIVER AND ATLANTIC OCEAN ACROSS THE PENINSULA OF FLORIDA.

The river and harbor act of March 3, 1875, appropriated $50,000 for examinations and surveys directed to be made at forty-six localities designated in the act. As this amount was insufficient to enable this office to comply with so much of the act as required "surveys and examinations to ascertain the practicability and cost of an inland water-communication between the Mississippi River and the Atlantic along the Gulf of Mexico and across the peninsula of Florida," which from their extent would have necessarily consumed much of the appropriation, to the exclusion of a number of other localities requiring examination, to supply the omission a communication was submitted to the House of Representatives at its last session, containing copies of reports heretofore made to Congress upon results of surveys for a canal-route across Florida, in compliance with acts of March 3, 1826, and of August 30, 1852, together with copies of reports from Captains Howell and Damrell, Corps of Engineers, made in 1873, in reference to portions of the route in question. This communication was printed in H. R. Ex. Doc. No. 157. (See also Appendix I 8.)

IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER—IMPROVEMENT OF ENTRANCE TO GALVESTON HARBOR, OF RED-FISH BAR, AND OF CHANNELS IN GALVESTON BAY, AND OF SABINE PASS, TEXAS.

Officer in charge, Capt. C. W. Howell, Corps of Engineers, having under his immediate orders Lieut. C. E. L. B. Davis, Corps of Engineers, and also Lieut. J. B. Quinn, Corps of Engineers, to May 20, 1876.

1. *Improvement of the mouth of the Mississippi at Southwest Pass.*—The work of dredging at Southwest Pass was continued during the year, resulting in a more uniform depth and width of channel over the bar than has been reported for any previous year, notwithstanding the increased volume of discharge and greater velocity of current through this pass, and therefore increased amount of deposit on its bar.

During the year there has been an absence of the disastrous blockades on the bar, so common heretofore, which, together with the more uniform channel, may be attributed to the general observance of the

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regulations established by the Secretary of War for the use of the channels dredged.

The dredge-boat Essayons was thoroughly repaired, and is considered by the officer in charge as good as new.

After some comparatively slight repairs to the dredge-boat McAlester, the two vessels will be in excellent condition for work during the present fiscal year.

The United States end-dock has been of great service to the work, netting, as reported to this office, up to the end of the year, a saving to the work of $39,431.

The coal-barge employed as a tender to the dredge engaged on the bar is becoming unserviceable, and it may be necessary to purchase a new vessel to replace the old one during the present fiscal year.

Surveys at the various passes were continued at intervals during the greater portion of the year.

Amount available July 1, 1875	$261,707 59
Amount expended during fiscal year ending June 30, 1876	226,687 40
Amount available July 1, 1876	35,020 19
Amount appropriated by act approved August 14, 1876	100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	150,000 00

(See Appendix J 1.)

2. *Improvement of Galveston Harbor, Texas.*—The work designed for improvement of the channel across the inner bar, which obstructs the entrance to the harbor, was pushed forward with energy until the 14th of September. At this date a very severe storm set in and destroyed property belonging to the work estimated in value at about $50,000.

There were saved from the material and appliances provided for the work and the manufacturing grounds, only one tug-boat, an unfinished steam-launch, two scows, the machinery of the sand-dredge, some small boats, a number of finished gabions, and a small amount of lumber, &c.

The gabions saved were found filled with sand, from the waves that dashed over them during the storm, and although but slightly injured, may be considered a loss, inasmuch as it will cost nearly their value to remove them from the sand in which they are embedded, wash out the sand filling them, and move them to a point where they can be utilized.

As soon after the storm as practicable an examination of the work previously put in position was made, and it was found to have suffered no material injury.

Such great changes, however, had been made in the general features of the east end of Galveston Island, and in the channels and shoals about the entrance to the harbor, that it was thought advisable to make a resurvey of the localities affected, and afterward recommit the questions touching this work of improvement to the Board of Engineers first convened to consider it, for opinion before recommencing the work of construction.

Pending this, authority was given to prepare for resumption of work.

The Board of Engineers was reconvened in New York City December 20, 1875, and, after careful consideration of the facts presented, adhered to its original recommendations, and made suggestions as to changes in details of construction. (For the report of the Board see Appendix J 3.)

Authority was then given to secure grounds on Bolivar Peninsula, to collect outfit and material, and to recommence manufacture and construction in accordance with the approved views of the Board.

This labor steadily progressed, and at the close of the year everything was in readiness to proceed with construction, which, however, has been delayed because of smallness of balance of appropriation, which it was

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found advisable to hold to provide for care of property on hand and to complete a survey in progress.

As the months of May, June, July, and August, are the most favorable for construction, the delay is to be regretted.

The work already constructed has produced a navigable channel across the inner bar 16½ feet in depth at mean low-tide, equal to nearly 18 feet at average flood-tide, where, before the commencement of the work, there was but scant 12 feet.

To secure a 20-foot channel at average flood-tide there remains to be removed a little over 2 feet from a bar only 450 feet in width, separating the harbor from Bolivar Channel.

The Cylinder Channel across the outer bar was deepened $\frac{9}{10}$ foot by the storm of September, considerably widened, and has since retained its increased dimensions, while other channels were impaired by the storm.

The appropriation made for the present year can be applied at once, and, with a small amount deducted for expense of management and surveys, will be applied to manufacture and construction.

The work for the inner-bar improvement will be completed, and that for improvement of the outer bar pushed as far as the amount appropriated will permit.

The importance of the work has been as fully stated as possible in previous reports.

It is thought that the inner-bar work is susceptible of permanent completion, while that projected for the outer bar may require, after construction, occasional extension to maintain its efficiency.

Amount available July 1, 1875	$141,951 49
Amount expended during fiscal year ending June 30, 1876	123,201 51
Amount available July 1, 1876	18,749 98
Amount appropriated by act approved August 14, 1876	142,000 00
Amount (estimated) required for completion of existing project	209,700 00
Amount that can be profitably expended in fiscal year ending June 30, 1877	209,700 00

(See Appendixes J 2 and J 3.)

3. *Improvement of Red Fish Bar in Galveston Bay, Texas.*—This work, as also the work for "improving the ship-channel between the mouth of San Jacinto River and Bolivar Channel," was done by contract.

It forms a portion of the ship-channel through Galveston Bay, and with it has made a continuous channel through the bar, and above and below it, in Galveston Bay.

Amount available July 1, 1875	$9,760 22
Amount expended during fiscal year ending June 30, 1876	9,760 22

(See Appendix J 4.)

4. *Improvement of the ship-channel between the mouth of San Jacinto River and Bolivar Channel, in Galveston Bay, Texas.*—This work was performed under contract, and completed as far as the appropriation would permit February 7, 1876.

The channel dredged is 6,100 feet in length and has a minimum depth of 14¼ feet at mean low-tide. It connects depths of 9 feet and 8½ feet in the upper and lower bays, and with the private work of improvement at Morgan's Point, permits the passage of vessels of 9 feet draught to within a few miles of Houston, Texas, with which it is designed to connect it by a short railroad.

The officer in charge recommends that any appropriation that may be made for the present year be applied in making a 12-foot channel in extension of the channel reported, and that the upper terminus of the

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channel be made at the cut through Morgan's Point instead of at the mouth of the San Jacinto River. This recommendation is concurred in.

The officer in charge also submits the following reduced estimates for completion of the work:

For completion of 9-foot cut through bar, 34,000 cubic yards excavation, at 30 cents	$10,200 00
For a 12-foot channel from Bolivar Channel to Morgan's Point, 2,171,874 cubic yards excavated, at 30 cents	651,562 20
For a 15-foot channel from Bolivar Channel to Morgan's Point, 4,200,207 cubic yards excavated at 30 cents	1,260,062 10
Amount available July 1, 1875	25,000 00
Amount expended during fiscal year ending June 30, 1876	25,000 00
Amount appropriated by act approved August 14, 1876	72,000 00
Amount (estimated) required for completion of existing project	554,560 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	250,000 00

(See Appendix J 5.)

5. *Improvement of Sabine Pass, Texas.*—By the contract for dredging the bar at the mouth of this pass, work was to be commenced on October 1, 1875, but owing to alleged difficulty in procuring boats the contractors did not do so until the latter part of February, 1876. The delay, however, was not of much consequence, as it covered a portion of the most difficult season of the year for work at Sabine Pass.

Since commencing the work great delay has been occasioned by storms and breakage of machinery; 23,294 cubic yards of material is reported as having been excavated up to June 30, 1876.

Amount available July 1, 1875	$20,000 00
Amount expended during fiscal year ending June 30, 1876	3,341 16
Amount available July 1, 1876	16,658 84
Amount appropriated by act approved August 14, 1876	38,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	29,500 00

(See Appendix J 6.)

IMPROVEMENT OF OUACHITA AND YAZOO RIVERS—REMOVAL OF RED RIVER RAFT—IMPROVEMENT OF TONES BAYOU AND CYPRESS BAYOU, RED RIVER, AND CONSTRUCTION OF DAM AT FOOT OF SODO LAKE—WATER-GAUGES ON THE MISSISSIPPI RIVER AND ITS PRINCIPAL TRIBUTARIES.

Officer in charge, Capt. W. H. H. Benyaurd, Corps of Engineers.

1. *Improvement of Ouachita River in Louisiana and Arkansas.*—Operations during the year were continued with the snag-boat in clearing the river of its most dangerous obstructions in the way of snags and wrecks. Some work was also attempted in Bayou Bartholomew, the most important tributary of the Ouachita, but the stage of water would only permit little work to be done.

During the coming season it is proposed to operate with the snag-boat as heretofore.

Amount available July 1, 1875	$18,485 49
Amount expended during fiscal year ending June 30, 1876, Louisiana, $15,728.08; Arkansas, $2,399.38	18,127 46
Amount available July 1, 1876	358 03
Amount appropriated by act approved August 14, 1876	12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	30,000 00

(See Appendix K 1.)

2. *Improvement of Yazoo River, Mississippi.*—The appropriation for this stream being insufficient to provide a new outfit and to do the work absolutely necessary, operations were carried on with the snag-boat, at

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a time when she could be conveniently spared from the Ouachita River, and consisted of the removal of snags, logs, overhanging trees, and portions of wrecks of steamers Star of the West and Capitol. If the improvement of this river is continued, operations will be similar during the coming season.

The Yazoo River has important tributaries, such as the Big Sunflower, Tallahatchie, &c., which are navigated by the same steamers that ply on the main river, and as it is equally important to have them also improved, it is suggested that in the event of future appropriations the benefits thereof be extended to them.

Amount available July 1, 1875	$11,616 47
Amount expended during fiscal year ending June 30, 1876	11,616 47
Amount appropriated by act approved August 14, 1876	15,000 00
Amount (estimated) required for completion of existing project	93,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

(See Appendix K 2.)

3. *Removing raft in Red River, Louisiana.*—Operations were continued at intervals during the season with the steamer Florence (which had been purchased to take the place of the Sterling, worn out in service) and with the crane-boat with full working force, in removing portions of the old raft, felling timber along the caving banks, removing jams to prevent the blockade of the river and the re-formation of the raft, and in pulling snags, which were the remains of the old raft.

During the coming season it is proposed to remove portions of the old raft still remaining, so as to make a channel 150 feet wide through the raft, and thus reduce the possibility of the river blocking up so easily; to cut down the willows and other small growth below Carolina Bluff, so as to allow the river to widen itself; to pull up the dangerous snags, and to cut the timber likely to cave into the river, above the head of the raft as far up as it is possible to work.

Amount available July 1, 1875	$39,354 91
Amount expended during fiscal year ending June 30, 1876	39,147 76
Amount available July 1, 1876	207 15
Amount appropriated by act approved August 14, 1876	35,000 00
Amount (estimated) required for completion of existing project	115,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	75,000 00

(See Appendix K 3.)

4. *Improvement of Cypress Bayou and construction of dams and dredging at foot of Sodo Lake, Texas.*—During July, operations were continued with the dredge-boat in finishing the cut that had been commenced the previous season, after which the dredge-boat was laid up and thoroughly repaired.

No work was done at the foot of Sodo Lake, there being no funds on hand for that purpose.

There has been no appropriation for this work since that for the fiscal year ending June 30, 1874.

It is proposed to apply the appropriation made for the fiscal year to dredging at various points in the bayou, and also to removing stumps and other obstructions in the lake.

Amount available July 1, 1875	$4,259 68
Amount expended during fiscal year ending June 30, 1876	4,237 58
Amount available July 1, 1876	22 10
Amount appropriated by act approved August 14, 1876	13,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	10,000 00

(See Appendix K 4.)

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5. *Water-gauges on the Mississippi River and its principal tributaries.*—Observations were continued at all the gauges. They are now in good condition, with the exception of that at Memphis, Tenn. This gauge will be put in good order so soon as the levee is repaired by the city, funds on hand being reserved for that purpose.

Amount available July 1, 1875	$5,927 63
Amount expended during fiscal year ending June 30, 1876	4,390 37
Amount available July 1, 1876	1,537 26
Amount that can be profitably expended in fiscal year ending June 30, 1878.	5,000 00

(See Appendix K 5.)

REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS, AND FROM WHITE AND SAINT FRANCIS RIVERS—IMPROVEMENT OF WHITE RIVER ABOVE JACKSONPORT, ARKANSAS.

Officer in charge, Major Charles R. Suter, Corps of Engineers.

1. *Mississippi, Missouri, and Arkansas Rivers.*—The snag-boats have worked during the past year in the Mississippi River, from Vicksburg, Miss., to Enterprise Island, a distance of 900 miles; in the Missouri River, from the mouth to Brunswick, Mo., 272 miles; and in Arkansas River, from the mouth to Pine Bluff, Ark., 172 miles. As much work was accomplished as was possible with the funds available, but it was neither as extensive nor complete as the interests of navigation demand.

During the present season, owing to the restrictions placed upon the expenditure of the appropriation made in the act of August 14, 1876, still less work than usual will be possible. Fifty thousand dollars is the sum allotted to this work, the greater portion of which will be expended upon the Mississippi.

The officer in charge urgently renews his recommendation that appropriations be made to enable him to replace the worn-out boats of the working fleet. Their wooden hulls have deteriorated to such an extent as to render them almost worthless for service, and the expense of keeping them afloat is a heavy tax on the annual appropriations. But one really efficient boat is available, the iron snag-boat J. N. Macomb, and the cost of her construction was charged to the current appropriations for running expenses, greatly crippling the work. Unless special appropriations are made for the purpose, the other worn-out boats must be replaced in the same manner, which will interfere seriously with the efficiency of the work. When the new boats needed are once built, it will be probably 20 or 30 years before they will require renewing, so that appropriations which are made for the work can be expended in the removal of obstructions.

Amount available July 1, 1875	$94,657 55
Amount expended during fiscal year ending June 30, 1876	90,998 57
Amount available July 1, 1876	3,658 98
Amount appropriated by act approved August 14, 1876	100,000 00

Amount required for the fiscal year ending June 30, 1878, viz:

For building one large iron-hulled snag-boat, to carry machinery of one of the present wooden boats	$140,000 00
For building one small iron-hulled snag-boat, to carry machinery of one of the present wooden boats	105,000 00
For building one small iron-hulled, stern-wheel snag-boat	60,000 00
For repairing one wooden snag-boat, and fitting it up for wrecking purposes	50,000 00
For working expenses of five boats, ten months each, at $4,000 per month	200,000 00
	555,000 00

(See Appendix L 1.)

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2. *White River, above Jacksonport.*—The small balance remaining of the appropriation for this work has been expended during the last fiscal year in caring for the Government property belonging to the improvement and in completing a report upon a plan of permanent improvement for this portion of White River.

With regard to the improvement of Upper White River the officer in charge estimates the cost of giving a navigable depth of 2½ feet from Jacksonport to Batesville, 2 feet from Batesville to Sylamore, and 18 inches from Sylamore to the head of Buffalo Shoals, at $710,234.37, the improvement to consist of dikes for concentrating the water and for reducing the local slopes. Before the work is commenced additional surveys are needed. For this and for snag-boat work an estimate for the coming fiscal year is submitted by the officer in charge.

Amount available July 1, 1875	$7,771 26
Amount expended during fiscal year ending June 30, 1876	7,771 26
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	710,234 37
Amount that can be profitably expended in fiscal year ending June 30, 1878.	57,700 00

(See Appendix L 2.)

3. *Improvement of White and Saint Francis Rivers.*—No appropriation has been made for work on these streams during the present season, but as work is much needed there the officer in charge submits an estimate for a snag-boat and expense of operating same.

For building one stern-wheel iron snag-boat	$60,000 00
For operating same 10 months, at $4,000 per month	40,000 00
	100,000 00

(See Appendix L 3.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of March 3, 1875, Major Suter was charged with and has submitted a report upon the *survey of Missouri River at the point where it is cutting into the Kansas shore above Saint Joseph's, Missouri.* (See Appendix L 4.)

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS—IMPROVEMENT OF OSAGE RIVER.

Officer in charge, Col. J. H. Simpson, Corps of Engineers, having under his immediate orders Capt. C. J. Allen, Corps of Engineers.

1. *Improvement of the Mississippi River between the mouths of the Illinois and Ohio Rivers.*—The unexpended balance of the appropriation of $15,000, of June 23, 1874, and the appropriation of $15,000, of March 3, 1875, for application between the Illinois and Missouri, were applied to the construction of a low dam at Piasa Island, with the exception of $197.30 used in repairs of the dam opposite Alton, and a small balance yet available for continuing work.

The further sum of $15,000 is provided by the act of August 14, 1876, for expenditure between the Illinois and Missouri. With this sum and the small balance of the previous appropriation, it is proposed to continue the construction of the dam at Piasa Island, and apply $1,500 to the necessary repairs and extension of the abutments of the dam opposite Alton.

Work at Sawyer Bend, in Saint Louis Harbor, was confined to an expenditure of $1,466.68 for repairs. The limited appropriation for the present year does not justify the continuation of work at this locality.

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The sum of $2,791.53 was applied to the partial restoration of the condition of Long Dike, near Venice, previous to its injury by ice in the spring of 1875. Further repairs are required to keep the dike at its proper height, which will involve an estimated expenditure of $2,500. No work is proposed here the present year.

Owing to changes at and near Arsenal Island, the condition of the channel at Horsetail Bar was very unfavorable during great part of the season of 1875. An additional dike was located and considerable progress made in its construction. The dikes contemplated in the original project at this locality have effected all that could reasonably be expected of them in their incomplete state. The foundations being well advanced, it is now necessary to raise the dikes to such height as may be found necessary to control the channel at the mean stage of water. Their influence hitherto being limited to low stages, the difficulties at the mean stage have not been removed. It is contemplated to raise the dikes and extend them to their full length as soon as possible.

The dams at Fort Chartres, Towhead, and Turkey Island are well advanced and can be completed the present year. The channel has continued good in the section of river which was expected to be improved by these works.

The channel at Liberty Island having changed, during the high water of 1875, from the east to the west side of the island, it became unadvisable to close the Missouri chute as contemplated, and it was thought best to devote the means allotted to the locality to the protection of the west bank opposite and above the head of the island. This protection was necessary to prevent the river getting into such condition as to render a return to the old channel impossible. Present appearances indicate that the west chute will remain the channel, rendering the extension of the protection necessary, which it is proposed to do the present year.

The works at Devil's Island were continued during the year. The channel was crooked, but the depth was maintained. The dike in the Missouri chute settled during the high water of 1875, and required a large amount of material to restore it to its former height. The construction of the dams in the Illinois chutes was succesfully continued.

New works have been authorized by Congress in the river and harbor act, approved August 14, 1876, at Cahokia Chute and Arsenal Island. The closure of Cahokia Chute cannot be undertaken with the means provided, which will all be required for the revetment of the island. The island is wasting rapidly, and causing great injury to the navigation of the river below. The closure of the chute is a work which must be done in one season, and therefore the appropriation of $75,000 is necessary in a single sum, if Congress sees fit to make a specific appropriation for the purpose.

Provision is made in the recent act requiring $5,000 to be expended between islands No. 14 and No. 15, near the town of Kaskaskia. This sum is insufficient to accomplish useful results, as it would be unsafe to place so small an amount of protection at the threatened point, lest it be flanked and detached from the shore, to be an obstruction to the channel.

A similar provision requires $30,000 to be expended for the protection of the banks between the foot of Dickey's Island and the mouth of the Ohio River, which will be done the present year. The commencement of this work will involve its continuation to the full extent estimated in the special report dated February 5, 1876. (See H. R. Ex. Doc. 126, 44th Congress, 1st session. See also Appendix M 4, of this report.)

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The officer in charge submits an estimate of $500,000 for the fiscal year ending June 30, 1878. This estimate is a reduction of preceding estimates of 50 per cent., and is submitted as the least amount that can be profitably expended. The necessary expenses of administration and repairs of existing works consume a considerable percentage of small appropriations, and, as the item of repairs must necessarily increase, the percentage so consumed must increase unless the appropriation be liberal enough to allow a vigorous prosecution of the works to completion.

The appropriation of the above sum is recommended.

Amount available July 1, 1875	$208,337 42
Amount expended during fiscal year ending June 30, 1876	192,612 74
Amount available July 1, 1876, including $2,133.38 due on contracts	15,724 68
Amount appropriated by act approved August 14, 1876	229,600 00
Amount (estimated) required for completion of existing project	6,279,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	500,000 00

(See Appendix M 1.)

2. *Improvement of Osage River, Missouri.*—The funds for this work were exhausted at the beginning of the fiscal year, and as Congress made no provision for further work, the property which had been used in the improvement and surveys was disposed of at public auction, and the proceeds, less expenses of sale, turned into the Treasury. (See Appendix M 2.)

3. *Survey of the Mississippi River, near Kaskaskia, Ill.*—Under an apprehension that a serious erosion might, at an early day, occur at the junction of the Kaskaskia with the Mississippi, at the request of the Representative in Congress from that district, Colonel Simpson was instructed to cause a special examination to be made of the locality, with the view of suggesting a remedy, if necessary. (For his report, see Appendix M 3.)

IMPROVEMENT OF THE UPPER MISSISSIPPI RIVER BELOW SAINT PAUL—IMPROVEMENT OF DES MOINES AND ROCK ISLAND RAPIDS OF THE MISSISSIPPI RIVER—IMPROVEMENT OF ILLINOIS RIVER.

Officer in charge, Col. J. N. Macomb, Corps of Engineers, having under his immediate orders Capt. Amos Stickney, Corps of Engineers.

1. *Improvement of Upper Mississippi River.*—The United States steamer Montana was employed, as heretofore, in rendering temporary aid to navigation in opening channels through bars by the use of Long's scraper, pulling snags, and removing overhanging trees, and also in building low dams and jetties, to contract the river and permanently improve the channel.

On account of the great age of the Montana, and the consequent increasing expense from year to year to repair and fit her for service, the officer in charge recommends the purchase of a new iron hull for her machinery, which is in excellent condition; also of new steel boilers. His estimate of the cost of new hull, boilers, and transfer of machinery, and for current expenses during the year is $91,500.

Amount available July 1, 1875	$23,539 49
Amount expended during fiscal year ending June 30, 1876	21,929 63
Amount available July 1, 1876	1,609 86
Amount appropriated by act approved August 14, 1876	30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	91,500 00

(See Appendix N 1.)

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2. *Improvement of Des Moines Rapids, Mississippi River.*—During the past season much work has been done in excavating prism of canal, building lock-gates, finishing the masonry of the guard-lock, and in excavating rock at Montrose Chain. This latter work proved far more expensive than was anticipated, owing to disasters experienced from unprecedented floods, and also in the discovery from new surveys of 25,000 more yards of rock to be taken out than had been called for by the surveys made several years ago, upon which the estimates were based.

Some 56,000 cubic yards of rock were taken out, and this portion of the work is nearly completed. Notwithstanding the numerous disasters, the rock was excavated by means of hired labor at about one-half of the usual cost of similar work done by contract.

For reasons above stated, an appropriation of $275,584 was asked for the fiscal year ending June 30, 1877, to complete this improvement. Of this sum, $230,000 was appropriated by the act of August 14, 1876, leaving a balance of $45,584, to which should be added $40,000, estimated, for the maintenance of the canal during the fiscal year ending June 30, 1878, making, in all, $85,584.

Operations for the completion of this improvement were necessarily suspended during the greater part of the present working season, until the appropriation of August 14, 1876, was made available. The consequence of this long suspension of operations has been unlooked-for injury to the work, to repair which, and to bring the work to its final completion, the officer in charge finds himself reluctantly forced to add to his former estimate the sum of $50,000, making in all the sum of $135,000, as required for the fiscal year ending June 30, 1878.

Amount available July 1, 1875	$582,889 88
Amount expended during fiscal year ending June 30, 1876	582,889 88
Amount appropriated by act approved August 14, 1876	230,000 00
Amount (estimated) required for completion of existing project	95,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878, including amount for annual maintenance	135,000 00

(See Appendix N 2.)

3. *Improvement of Rock Island Rapids, Mississippi River.*—During the year 2,340.5 cubic yards of rock at Lower Chain and 305.44 cubic yards of rock at Saint Louis Chain have been removed. The insufficiency of the appropriation of August 14, 1876, will only allow the removal of some rock-patches at Saint Louis, Campbell's, and Duck Creek Chains during the fiscal year 1876–'77.

The work closing the improvement consists of excavating 2,500 cubic yards of rock at the foot of Moline Chain, for the final accomplishment of which, and for meeting all probable contingencies in completing the work, the officer in charge asks an appropriation of $50,000 for the fiscal year ending June 30, 1878.

Amount available July 1, 1875	$52,432 03
Amount expended during fiscal year ending June 30, 1876	46,702 87
Amount available July 1, 1876, including $2,808.60 due on contracts	5,729 16
Amount appropriated by act approved August 14, 1876	25,000 00
Amount (estimated) required for completion of existing project	50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

(See Appendix N 3.)

4. *Improvement of Illinois River.*—The project for continuing the work of improving the river by dredging and building dams, jetties, and training-walls was successfully carried on, but not entirely completed, owing to suspension of work caused by long continuance of floods in the river. The sum of $120,000 is asked for completing this improvement.

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Amount available July 1, 1875	$113,126 42
Amount expended during fiscal year ending June 30, 1876	73,434 56
Amount available July 1, 1876, including $3,020.95 due on contracts	39,691 86
Amount appropriated by act approved August 14, 1876	40,000 00
Amount (estimated) required for completion of existing project	120,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	80,000 00

(See Appendix N 4.)

EXAMINATIONS FOR IMPROVEMENT.

In consequence of petitions from the mayor and aldermen of Fort Madison and from the authorities of Burlington, Iowa, at the request of the Representative in Congress from that district, and by direction of the Secretary of War, Colonel Macomb was instructed to make an examination of those localities and submit a plan for the improvement of the navigation of the Mississippi in their vicinity. (For his reports thereon, see Appendixes N 5 and N 6.)

And also, in consequence of a petition from merchants of Dubuque, and owners of a large number of steamboats plying the Upper Mississippi, at the request of the Hon. W. B. Allison, Senator from Iowa, Colonel Macomb was instructed, by direction of the Secretary of War, to make an examination of the harbor of Dubuque, with the view of devising a plan for the preservation of the landing from injury arising from changes in progress in the channels of the river at that point. (For his report, see Appendix N 7.)

PRESERVATION OF THE FALLS OF SAINT ANTHONY, AND IMPROVEMENT OF THE MISSISSIPPI ABOVE THE FALLS—CONSTRUCTION OF LOCK AND DAM AT MEEKER'S ISLAND—IMPROVEMENT OF MINNESOTA RIVER.

Officer in charge, Maj. F. U. Farquhar, Corps of Engineers.

1. *Preservation of the Falls of Saint Anthony.*—During the year the entire excavation for the concrete dike was made, and the dike itself completed, except the filling of the upper and lower passages; 8,377 cubic yards of concrete were put in place, and there remains about 3,000 cubic yards of concrete to be put in place to finish this portion of the work. The apron was repaired at a cost of $25,215.46, of which amount $1,500 were contributed by the citizens of Minneapolis.

The following work will be carried out during the fiscal year ending June 30, 1877, if funds become available:

1st. The dike will be completed.

2d. The rolling dams on the ledge above the Falls in the main channel will be built.

3d. The excavations under the lime-rock above the dike will be filled with gravel; and

4th. An extension of the apron will be constructed on the east side of the main channel.

An additional sum of $5,000 (being the balance remaining unappropriated of the estimate submitted in the last annual report) will be required during the next fiscal year.

Amount available July 1, 1875	$135,106 76
Amount expended during fiscal year ending June 30, 1876	132,044 38
Amount available July 1, 1876, including $511.70 due on contracts	3,062 38
Amount appropriated by act approved August 14, 1876	120,000 00
Amount (estimated) required for completion of existing project	184,726 35
Amount that can be profitably expended in fiscal year ending June 30, 1878	5,000 00

(See Appendix O 1.)

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2. *Improvement of Mississippi River above Falls of Saint Anthony.*—No work of improvement was carried on during the fiscal year, as the amount available from the appropriation made in 1874 was not sufficient, and it was deemed necessary to expend the total sum appropriated by the act of March 3, 1875, on the work at the Falls of Saint Anthony. The river was gauged for the purpose of determining the high and low water discharges. An additional appropriation of $55,000 is required.

Amount appropriated by act approved August 14, 1876	$20,000
Amount (estimated) required for completion of existing project	55,000
Amount that can be profitably expended in fiscal year ending June 30, 1878	55,000

(See Appendix O 2.)

3. *Construction of lock and dam on Mississippi River at Meeker's Island, Minnesota.*—No work has been done here, as no funds were available, because the parties holding the land-grant have not made any acceptable release as required by the act approved March 3, 1875. The State of Minnesota should annul the grant to the parties now holding the land-grant, and release the same to the United States.

To carry on this work, a sum not less than $300,000 should be appropriated for the fiscal year ending June 30, 1878.

Amount available July 1, 1876	$25,000 00
Amount (estimated) required for completion of existing project	922,121 46

(See Appendix O 3.)

4. *Improvement of Minnesota River.*—A contract has been made for removing snags, bowlders, and overhanging trees from the river and its banks. Under this contract all the snags and bowlders in low-water channel, and overhanging trees on the banks of the river, were removed between Mankato and a point 20 miles below It is not deemed necessary to commence the improvement of the navigation of the river until the lock and dam at Little Rapids are built. The expenditure of the last appropriation of $10,000 will be deferred until next season, when, should an additional appropriation of $50,000 be made, the lock and dam can be commenced, otherwise the available funds will be used in continuing the removal of snags, boulders, &c., below the point already reached.

Amount available July 1, 1875	$9,620 84
Amount expended during fiscal year ending June 30, 1876	9,577 38
Amount available July 1, 1876, including $29.02 due on labor and materials	43 46
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project, lock and dam at Little Rapids	127,463 05
Amount that can be profitably expended in fiscal year ending June 30, 1878, lock and dam at Little Rapids	60,000 00

(See Appendix O 4.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of March 3, 1875, Major Farquhar was charged with the survey of *Chippewa River, Wisconsin*, the results of which were transmitted to Congress at its last session in a report which was printed in H. R. Ex. Doc. No. 68.

(See Appendix O 5.)

IMPROVEMENT OF THE TENNESSEE AND CUMBERLAND RIVERS, AND OOSTENAULA AND COOSAWATTEE RIVERS, GEORGIA.

Officer in charge, Maj. Walter McFarland, Corps of Engineers, with Capt. L. C. Overman, Corps of Engineers, under his immediate orders.

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Major McFarland was relieved from the charge of these works May 15, 1876, by Capt. W. R. King, Corps of Engineers.

1. *Tennessee River above Chattanooga.*—This improvement consists in deepening the channel at the numerous shoals by building stone dams to contract the waterway, in blasting rock from the channel, and removing sand-bars, so as to secure at least 3 feet of water at all stages between Chattanooga and Knoxville.

Work of this character being difficult to contract for, the officer in charge has been directed to carry it on by hired labor. The progress during the fiscal year was satisfactory. That portion of the river between Chattanooga and Kingston, where the improvements are nearest completion, can now be navigated during the whole year by steamers drawing nearly 3 feet of water, and as the work is extended toward Knoxville, there is every reason to expect that the same success will attend it.

Amount available July 1, 1875	$35,856 27
Amount expended during fiscal year ending June 30, 1876	27,994 26
Amount available July 1, 1876	7,862 01
Amount appropriated by act approved August 14, 1876	15,000 00
Amount (estimated) required for completion of existing project	75,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	35,000 00

(See Appendix P 1.)

2. *Tennessee River below Chattanooga, including Muscle Shoals.*—To the end of the fiscal year the work completed in the enlargement and repair of the old canal is as follows:

Earth excavation	253,284 cubic yards.
Earth embankment	111,484 cubic yards.
Rock excavation	7,598 cubic yards.
Slope wall built	575 cubic yards.
Removal of old locks	425 cubic yards.
Grubbing and clearing	84.6 acres.

This work is done by contract.

Colbert Shoals.—The work in this vicinity, being similar to that upon the Upper Tennessee, is done by hired labor. It was much delayed early in the season by continued high water, but, nevertheless, a fair progress has been made in deepening the channel and in the extension of the dams so as to secure a sufficient depth of water.

The estimate submitted by the officer in charge of the amount required for the fiscal year ending June 30, 1878, includes work at this point as well as at Muscle Shoals.

Amount available July 1, 1875	$499,263 73
Amount expended during fiscal year ending June 30, 1876	139,327 81
Amount available July 1, 1876, including $10,231.56 due on contracts	359,935 92
Amount appropriated by act approved August 14, 1876	255,000 00
Amount (estimated) required for completion of existing project	3,304,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	745,000 00

(See Appendix P 2.)

3. *Improvement of Cumberland River below Nashville.*—The working-season of the fiscal year was very unfavorable for the prosecution of this work, channel-excavation having been almost impracticable during the whole year. The principal work of the season comprised building dams and excavating rock at Harpeth Shoals and Davis's Ripple.

Amount available July 1, 1875	$25,356 86
Amount expended during fiscal year ending June 30, 1876	12,365 25
Amount available July 1, 1876	12,991 61
Amount (estimated) required for completion of existing project	184,821 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	75,000 00

(See Appendix P 3.)

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4. *Improvement of Oostenaula and Coosawattee Rivers.*—This work was continued during the year until the balance of available funds was exhausted. It consisted generally in the building of small riprap dams, the removal of rock, snags, and gravel from the channels and of overhanging trees from the banks.

From examinations heretofore made it would require an additional appropriation of $13,200 to complete the work of improvement of these rivers as originally proposed.

Amount available July 1, 1875	$7,552 05
Amount expended during fiscal year ending June 30, 1876	7,529 99
Amount available July 1, 1876	22 06
Amount (estimated) required for completion of existing project	13,208 50
Amount that can be profitably expended in fiscal year ending June 30, 1878.	13,200 00

(See Appendix P 4.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of March 3, 1875, Major McFarland was charged with the following:

1. *Examination of Little Tennessee River from the Chilhowee Mountains to the Georgia line, in Macon County, North Carolina.*
2. *Continuing survey of French Broad River from Henderson County line, Tennessee.*
3. *Examination of French Broad River from Knoxville to Leadvale, Tennessee.*
4. *Examination of Ocmulgee River, Georgia, from Macon to Covington.*
5. *Examination of Powell's River from the Three Forks, in Wise County, Virginia, to the mouth of Clinch River, Tennessee.*
6. *Examination of Clinch River from the mouth of Indian, in Tazewell County, Virginia, to the junction of Clinch and Powell's Rivers, Tennessee.*
7. *Examination of Clinch River below the mouth of Emery's River, and Emery's River above its mouth, for the removal of bars, Tennessee.*

The results of these examinations were transmitted to Congress at its last session, in reports which were printed in H. R. Ex. Docs. Nos. 141 and 188. (See also Appendixes P 5, P 6, P 7, and P 8.)

IMPROVEMENT OF THE NAVIGATION AT THE FALLS OF THE OHIO RIVER—SUPERINTENDENCE AND MANAGEMENT OF THE LOUISVILLE AND PORTLAND CANAL.

Officer in charge, Maj. G. Weitzel, Corps of Engineers, having Capt. Alexander McKenzie, Corps of Engineers, under his immediate orders.

1. *Improvement of the Falls of the Ohio.*—During the year 613 cubic yards of rock excavation were made inside of the apron-dam at the head of the canal. Repeated rises in the river and misfortune arising from a large break in the coffer-dam, prevented more from being done.

No further appropriation is required for this work.

Amount available July 1, 1875	$102,459 32
Amount expended during fiscal year ending June 30, 1876	12,710 02
Amount available July 1, 1876	89,749 30

(See Appendix Q 1.)

2. *Superintendence, management, and repair of the Louisville and Portland Canal.*—During the year 3,233 boats have been passed through the locks, and 103,603 cubic yards of sediment have been removed by the dredges. The mechanics have been employed in repairs on all parts of

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the machinery and accessories of the canal, and in making new machinery and tools; the laborers, in passing and docking boats and in general work; the mud-scows have been enlarged and thoroughly repaired; the tug-boat Walker Morris completely rebuilt and improved. One dredge has been thoroughly repaired and improved.

A machine-shop, with machinery and labor-saving apparatus, has been erected, a fire-cistern has been built, a telegraph-line has been constructed, and osage-orange hedge planted along the canal.

A loan of $50,000, to be repaid from time to time as the surplus of tolls will warrant, is needed for this work.

Cash on hand July 1, 1876 ..... $28,017 19

(See Appendix Q 2.)

IMPROVEMENT OF THE OHIO, MONONGAHELA, AND WABASH RIVERS.

Officer in charge Maj. W. E. Merrill, Corps of Engineers, having under his immediate orders Lieut. F. A. Mahan, Corps of Engineers.

1. *Improvement of the Ohio River.*—The contracts outstanding at the end of the last fiscal year were for the extension of the French Island dike; the completion of the dike at Evansville; the completion of a dike at Henderson Island, and the construction of a dam at the same place.

The French Island dike has been extended 1,518 feet, making a total length of 3,498 feet, or two-thirds of a mile. The result thus far has been quite satisfactory.

Very little was done at the Evansville dike beyond repairing damages and stopping a threatened scour below the shore-end. The flood of August so reduced the working-season that no work could be done on the proposed extension of 500 feet. The dike has done excellent service, and it is believed that when extended as proposed the Evansville bar will be entirely removed. Its present length is 1,525 feet.

The dike at Henderson Island has been completed, its total length being 1,900 feet. It has had an excellent effect on the bar on which it is built, but it has but little effect on the bar at the foot of the island, and it will probably be necessary to build another dike about 4,000 feet below the present one in order to remove this obstruction.

The dam behind Henderson Island has been repaired and completed. Its length is 620 feet, and its width 50 feet. It has fully accomplished its object of forcing all the water, at stages below 6 feet, to pass alongside of the dike.

The snag-boat E. A. Woodruff has been completed and put in commission. From the 8th to 30th of June, she had removed 123 snags and 2 wrecks, and is still at work doing good service to Ohio River commerce.

The Government dredges Ohio and Oswego have been in constant service, except during the months of ice and high water. During the fiscal year they have dredged the following from the channel:

	Cubic yards.
Saw Mill Run	19,201
Brunót's Island	25,173
Deadman's Island	22,807
White's Bar	8,329
Hay's Bar	29,961
Deadman's Island	15,330
Raccoon Island	6,940
Total	127,741

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The average cost per cubic yard during the year 1875 was 17 cents.

The dredges also removed from the channel 11 wrecks and 6 snags.

Forty-three snags and one rock-heap were removed by special contract during the autumn of 1875, before the snag-boat was completed.

During the fiscal year two contracts were made for the removal of wrecks in the Lower Ohio. One contractor failed to procure bondsmen, and did no work. The other, at the close of the fiscal year, had removed 3 wrecks, and since June 30, he has completed his contract.

No work was done on the first movable dam on the Ohio, (for which $100,000 was allotted,) because the legislature of Pennsylvania failed to pass an act giving cession of jurisdiction and power to condemn the necessary land. The report contains an account of the steps taken to secure the required legislation.

For the report of the board of engineer officers convened to examine and report upon and which adopted the plan and location of this dam, as proposed by Major Merrill, see Appendix R 2.

During the early part of 1876 Lieutenant Mahan, whilst on leave of absence, made a special examination of the various movable dams now in operation in France. In consequence of the information he obtained, (see Appendix R 1,) and of information from other sources, it is now proposed by the officer in charge to replace the maneuvering-boat by a service bridge, and to crown the high wier with a Poirée dam, using either needles or the gates invented by M. Boulé, as may be subsequently determined. A new estimate for this dam is therefore submitted by Major Merrill. Its total cost, including the dam behind Davis Island, is put at $465,000, of which $99,845 is now on hand.

The removal of the dam at Cumberland Island is strongly recommended by the officer in charge, on the ground that it is a serious injury to the navigation of the Ohio, and that the reasons that originally caused its construction no longer exist.

The officer in charge submits the following estimate for the fiscal year 1877–'78:

For snag-boat, dredges, and office	$100,000 00
For riprap, dams, and dikes	185,000 00
For completion of movable dam at Davis Island	365,000 00
Total amount required	650,000 00

A translation from the *Annales des ponts et chaussées*, containing a full account of the modification in the needle-dams invented by M. Boulé, accompanies this report as Appendix R 3.

Amount available July 1, 1875	$274,611 40
Amount expended during fiscal year ending June 30, 1876	157,590 45
Amount available July 1, 1876, including $8,688.16 due on contracts, &c	117,020 95
Amount appropriated by act approved August 14, 1876	175,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	650,000 00

(See Appendix R 1.)

2. *Improvement of the Monongahela River.*—The work on this river consists in completing lock and dam No. 9 at Hoard's Rocks, West Virginia, ninety-four miles above Pittsburgh, and eight and a half miles below Morgantown.

The lock has been finished except the miter and lift walls, which were not embraced in the contract. For reasons set forth at length in the report of the officer in charge, an additional appropriation of $20,000 will be required to complete this lock and dam.

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Estimate for the fiscal year 1877-'78.

For completion of lock and dam at Hoard's Rocks	$20,000 00
For lock at Laurel Run, (omitting miter-walls, gates, and valves)	60,000 00
Total amount required	80,000 00
Amount available July 1, 1875	101,286 09
Amount expended during fiscal year ending June 30, 1876	63,471 48
Amount available July 1, 1876, including $2,601.16 due on contracts, &c	37,814 61
Amount that can be profitably expended in fiscal year ending June 30, 1878.	80,000 00

(See Appendix R 4.)

3. *Improvement of the Wabash River.*—The outstanding contracts at the beginning of the fiscal year were for clearing out the Little Cut-off, for closing the New Harmony Cut-off by a dam, and for excavating a channel at Warwick's Ripple.

The contract at Little Chain was completed.

At New Harmony the dam was only partly built when the season closed. Some damage was done to it during the winter, but this has been repaired, and the dam will probably be finished by the end of the year.

At Warwick's Ripple no work of excavation was done during the last season, as the contractor failed to get his coffer-dam dry. He is again at work, but thus far has done but little. The prospect of finishing the work by the close of the present season is unfavorable.

Estimate for fiscal year 1877-'78.

For rebuilding Grand Rapids lock	$130,000 00
For engineering and contingencies	15,000 00
Total amount required	145,000 00
Amount available July 1, 1875	49,917 03
Amount expended during fiscal year ending June 30, 1876	15,802 15
Amount available July 1, 1876, including $271.88 due on contracts	34,114 88
Amount appropriated by act approved August 14, 1876	70,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	145,000 00

(See appendix R 5.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the act of March 3, 1875, Major Merrill was charged with the completion of the surveys begun under the act of June 23, 1874, for the extension of the *Chesapeake and Ohio Canal from Cumberland, Maryland, to the headwaters of the Youghiogheny River.* The final report was transmitted to Congress at its last session, and printed in H. R. Ex. Doc. No. 137. (See Appendix R 6.)

Also with the *survey of Monongahela River from Morgantown to Fairport, West Virginia,* and an *examination of the Louisa Fork of Sandy River from the mouth of Dismal, in Buchanan County, Virginia, to Piketon, Kentucky,* the results of which were transmitted to Congress in reports printed in H. R. Ex. Doc. No. 91. (See Appendixes R 7 and R 8.)

And also with an examination of *Allegheny River below Freeport, Pennsylvania,* and the *survey of Allegheny River near Pittsburgh.* (See Appendix R 9.)

IMPROVEMENT OF GREAT KANAWHA RIVER, WEST VIRGINIA, AND OF NEW RIVER, VIRGINIA AND WEST VIRGINIA.

Officer in charge, Maj. W. P. Craighill, Corps of Engineers, with Lieut. Thomas Turtle, Corps of Engineers, under his immediate orders.

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1. *Improvement of Great Kanawha River, West Virginia.*—Three hundred thousand dollars was appropriated March 3, 1875. As soon as was possible, the possession of sites for beginning operations was obtained. The necessary legal process caused some delay. Contracts were made as follows: August 20, 1875, for building a large lock near Brownstown; October 15, 1875, for building a similar lock near the foot of Cabin Creek Shoal; March 28, 1876, for building a dam, abutment, pier, and the floor of a navigation-pass adjoining the lock at Brownstown. The contract-prices were lower than the estimates of the engineer. Financial difficulties and other troubles have caused delay, but it is expected that the works contracted for will be so far advanced in the working-season of 1876 as to be essentially completed in 1877. The next operations to be undertaken should be the building of the dam, &c., adjoining the lock near Cabin Creek Shoal, and the occupation of one or more other of the locations of the series. The late date at which the new appropriation was made will cause delay in bringing on the work, which, in the earlier stages at every location, can only be done at the lowest stage of the water, a period of brief duration in each year on this river.

A small sum was expended in the last fiscal year in ameliorating the condition of some of the worst shoals which obstruct navigation at points not affected by the permanent works now in hand. The same plan will be pursued in the current fiscal year.

The appropriations have been, March 3, 1873, $25,000; June 23, 1874, $25,000; total for temporary improvement, $50,000.

The first appropriation for the permanent improvement was $300,000, March 3, 1875; another made August 14, 1876, of $270,000. The total of the estimate for the permanent improvement is $4,152,000.

Amount available July 1, 1875	$302,753 62
Amount expended during fiscal year ending June 30, 1876	31,293 13
Amount available July 1, 1876, including $665.48 due on contracts	271,460 49
Amount appropriated by act approved August 14, 1876	270,000 00
Amount (estimated) required for completion of existing project	3,852,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	1,000,000 00

(See Appendix S 1.)

2. *Improvement of New River from the lead-mines in Wythe County, Virginia, to the mouth of the Greenbrier River, in West Virginia.*—Special reports as to this portion of the river were made December 20, 1872, and January 9, 1873, which were printed in the annual report of the Chief of Engineers for 1873. Those reports, with their maps and sub-reports, contain the latest official information on the subject.

Two plans were recommended for consideration—a 2-feet keel-boat navigation, costing $100,000, and a 3-feet steamboat navigation, costing $1,000,000. It was also stated, as an approximation, that a 5½-feet steam-navigation would cost about $2,500,000. No decision has yet been arrived at as to the best method of expending the small appropriation of $15,000 made by act of August 14, 1876.

Amount appropriated by act approved August 14, 1876	$15,000
Amount (estimated) required for completion of existing project, (see report above; depends on plan adopted)	
Amount that can be profitably expended in fiscal year ending June 30, 1878	50,000

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Craighill submitted December 7, 1875, a report of the *survey of Elk River, in West Virginia, between its mouth at Charleston and Braxton Court-House.* (See Appendix S 2 to this report, as also Ex. Doc. No. 69, H. R. 44th Cong., 1st sess.)

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TRANSPORTATION-ROUTES TO THE SEABOARD.

The act of June 23, 1874, provided for surveys and estimates to be made, for the improvement recommended by the Senate Select Committee on Transportation-Routes to the Seaboard, upon certain routes indicated by the committee.

Upon the receipt of each report, whether upon an entire route or any portion of it, it was submitted by the Secretary of War to Congress and printed, the whole forming a series of executive documents, which were also inserted in the appendix of my last annual report.

Upon the *third subdivision of the Mississippi route*, surveys were continued during the last fiscal year, under the direction of Col. J. N. Macomb, Corps of Engineers, from La Crosse, Wis., to Des Moines Rapids, at which point the work was discontinued, the available funds having been exhausted.

The report of the results of this survey will be found in Appendix T 1.

Upon the *third subdivision of the central route*, designated as "a connection by canal or a freight-railway from the Ohio or Kanawha River, near Charleston, by the shortest and most practicable route through West Virginia to tide-water in Virginia," the surveys for which were assigned to Maj. William B. Craighill, Corps of Engineers, the study of the subject has been continued by him, and a further report will be submitted at an early day.

In connection with the *first subdivision of the northern route*, a report to this office from Maj. G. K. Warren, Corps of Engineers, upon the improvement of the route of water-transportation between the Mississippi and Lake Michigan along the valleys of the Fox and Wisconsin Rivers, was transmitted to Congress at its last session, and printed as Senate Ex. Doc. No. 28.

The conclusions reached by Major Warren are adverse to the permanent improvement of the Wisconsin River by a system of canalization or rectification of its high and low water channels, and that a canal along its banks is the only method of permanent improvement.

The improvement of this route is now in progress, in charge of Maj. D. C. Houston, Corps of Engineers. The present method of improvement of the Wisconsin is on trial on its own merits, and it is too soon to announce the final result; but the publication of this report, with the data it contains, will enable others to form an opinion of the nature of the undertaking, and aid in a more speedy solution.

(See Appendix T 2.)

BRIDGING THE NAVIGABLE WATERS OF THE UNITED STATES.

To comply with acts of Congress relative thereto, the attention of this office has been called by the Secretary of War to questions arising in the proposed construction of bridges across navigable streams. (See Appendix U 1.)

The reports of boards of engineer officers convened to consider some of the proposed plans of bridges, will be found as below:

1. *Bridge across Ohio River at Cincinnati*, proposed by the Cincinnati Southern Railway Company. (See Appendix U 2.)
2. *Bridge across Mississippi River at Dubuque*, proposed by the Dubuque and Dunleith Pile and Ponton Bridge Company. (See Appendix U 3.)
3. *Bridge across the Saint Croix River at Stillwater, Minnesota.* (See Appendix U 4.)

And also an examination of the harbor of Saint Joseph, Mich., and of the construction of the railroad-bridge across that harbor, with the

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view of ascertaining whether the bridge materially affects the commerce of the harbor, and, if so, in what manner its construction can be modified. (See Appendix U 5.)

LAKE HARBORS AND RIVERS.

HARBOR-IMPROVEMENTS AT SUPERIOR CITY, SUPERIOR BAY, AND DU LUTH, LAKE SUPERIOR.

Officer in charge, Maj. F. U. Farquhar, Corps of Engineers.

1. *Du Luth Harbor, Minnesota.*—The contract for dredging in the anchorage south of the channel leading from the canal to the railroad-docks has been continued during the fiscal year, the whole amount of dredging to the end of the year being 169,544 cubic yards.

The piers of the canal continue in the same precarious state, from being undermined by the current. For protection, some 200 cords of stone have been placed on the channel side of the north pier by the Lake Superior and Mississippi Railroad Company.

The appropriation for the present fiscal year will be expended in repairs to the north pier of the canal and in dredging.

Amount available July 1, 1875	$34,449 83
Amount expended during fiscal year ending June 30, 1876	29,874 44
Amount available July 1, 1876, including $258.33 due on labor	4,575 39
Amount appropriated by act approved August 14, 1876	15,000 00
Amount (estimated) required for completion of existing project	171,847 11
Amount that can be profitably expended in fiscal year ending June 30, 1878—dredging and repairs	60,000 00

(See Appendix V 1.)

2. *Natural entrance to Bay of Superior, Minnesota and Wisconsin.*—The work here consisted in protecting the beach between the light-house and the pier from the action of the sea breaking over it. The work was done by contract. It may be that this brush protection will have to be further extended toward the light-house.

There is a good channel of 12 feet in depth between the piers.

Future available funds will be used in repairs to piers and any work necessary to prevent a breach on Minnesota Point.

Amount available July 1, 1875	$5,433 00
Amount expended during fiscal year ending June 30, 1876	5,343 54
Amount available July 1, 1876	89 46
Amount appropriated by act approved August 14, 1876	3,000 00
Amount (estimated) required for completion of existing project—repairs	7,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	7,000 00

(See Appendix V 2.)

McCargoe's Cove, Isle Royale, Lake Superior.—In consequence of a petition to the Secretary of War from persons interested in the trade of Isle Royale, Major Comstock, Corps of Engineers, in charge of the survey of the northern and northwestern lakes, was instructed to estimate the cost of removal of certain obstructions to navigation at the entrance to McCargoe's Cove. (For his report, see Appendix V 3.)

HARBORS ON LAKE SUPERIOR, (EXCEPT DU LUTH AND SUPERIOR CITY,) ON GREEN BAY, AND ON THE WESTERN SHORE OF LAKE MICHIGAN, NORTH OF MILWAUKEE, WISCONSIN.

Officer in charge, Maj. Henry M. Robert, Corps of Engineers.

1. *Ontonagon Harbor, Michigan.*—The pile revetment, 498 feet long, on the shore end of the west pier was completed, 7 cribs on the west pier

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had superstructure built on them, 5 courses were put on the last crib of the east pier, and 6 courses of superstructure were put on the same; the east pier was refilled and planked, and 10 new cribs were placed in extension of the west pier.

This is an important work, as Ontonagon is the only harbor on a long stretch of coast. There remains yet to be appropriated of the original estimate for completing the work $208,170, and $30,000 is asked for by the officer in charge.

Amount available July 1, 1875	$35,369 35
Amount expended during fiscal year ending June 30, 1876	30,575 61
Amount available July 1, 1876, including $1,908.26 due on contracts	4,793 74
Amount appropriated by act approved August 14, 1876	15,000 00
Amount (estimated) required for completion of existing project	208,170 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	30,000 00

(See Appendix W 1.)

2. *Eagle Harbor, Michigan.*—The work of blasting the rock obstructing the entrance to this harbor was actively begun, and is still in progress, some $33,000 having accumulated from small appropriations. If funds should be available, the work will be continued as at present, leaving the dredging of the blasted rock until it can be removed in large quantities.

Amount available July 1, 1875	$28,913 52
Amount expended during fiscal year ending June 30, 1876	18,979 53
Amount available July 1, 1876	9,933 99
Amount appropriated by act approved August 14, 1876	12,000 00
Amount (estimated) required for completion of existing project	198,362 36
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

(See Appendix W 2.)

3. *Marquette Harbor, Michigan.*—The breakwater forming this harbor has been completed, including repairs, at a cost less than the original estimate by $78,873.83, and is 10 feet longer than was contemplated. During the year superstructure was built over crib No. 40; five intervals were refilled with stone; repairs made to the planking broken up by a severe storm, and 2,059¼ cords of stone were placed as riprap along the seaward face of the breakwater.

The recommendation made last year for an appropriation of $68,000 to build an extension of 400 feet is renewed. The large commercial interests of Marquette Harbor would seem to justify this extension of her harbor-room.

Amount available July 1, 1875	$17,536 41
Amount expended during fiscal year ending June 30, 1876	16,452 96
Amount available July 1, 1876	1,083 45
Amount appropriated by act approved August 14, 1876	2,000 00
Amount (estimated) required for completion of project recommended	68,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	35,000 00

(See Appendix W 3.)

4. *Menomonee Harbor, Michigan and Wisconsin.*—The contract entered into last year at low prices for dredging this harbor was extended to September 30, 1876. Ninety-three thousand four hundred and seventy-seven and two-tenths cubic yards were dredged at the expense of the Government during the past year, besides 47,000 cubic yards done by private enterprise. Two thousand linear feet of dock-line was built also by private enterprise. The dredging will be continued this season, and, if appropriation is made, the piers will be extended and plank walks laid on them. A great freshet in the river last May produced a partial

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undermining of some 300 linear feet of the south pier, which is now being repaired.

Amount available July 1, 1875	$27,918 12
Amount expended during fiscal year ending June 30, 1876	15,672 65
Amount available July 1, 1876, including $1,355.39 due on contracts	12,245 47
Amount appropriated by act approved August 14, 1876	8,000 00
Amount (estimated) required for completion of existing project	87,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	25,000 00

(See Appendix W 4.)

5. *Green Bay Harbor, Wisconsin.*—Dredging in the channel between Grassy Island and the mouth of the Fox River was continued during the season of 1875, 34,459 cubic yards of material having been removed during the fiscal year. The piers which preserve the cut at Grassy Island were seriously damaged last winter by ice. It is proposed to repair them and protect the east pier by continuing around it the guard-piling commenced in 1874, as soon as money becomes available, when dredging will also be continued.

This harbor should be pushed to an early completion, as, independently of the trade of the cities of Green Bay and Fort Howard, at its head, it forms the lake outlet of the Fox and Wisconsin River improvement.

A straight channel of 14 feet water through the flats is the object aimed at, and to preserve it when completed will require a small annual appropriation.

Amount available July 1, 1875	$10,014 10
Amount expended during fiscal year ending June 30, 1876	9,594 94
Amount available July 1, 1876	419 16
Amount appropriated by act approved August 14, 1876	8,000 00
Amount (estimated) required for completion of existing project	35,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	12,000 00

(See Appendix W 5.)

6. *Harbor of Refuge at Sturgeon Bay Canal, Wisconsin.*—There has been no appropriation for this work since 1874. The company having this ship-canal in charge has suspended work. If the canal is completed, the harbor will become an important point. The pile piers require repairs, and funds should be on hand to keep them in order in case of an emergency. Five thousand dollars are asked for this purpose.

Amount available July 1, 1875	$420 51
Amount expended during fiscal year ending June 30, 1876	19 30
Amount available July 1, 1876	401 21
Amount that can be profitably expended in fiscal year ending June 30, 1878—for repairs	5,000 00

(See Appendix W 6.)

7. *Aknapee Harbor, Wisconsin.*—Six cribs were placed in extension of the north pier, and one crib in the south pier. Eight sections of the south pier were refilled, and 17,315.2 cubic yards of sand and 158.96 cords of rock were excavated by the United States dredge from the channel.

A board of engineer officers was convened to report on a plan submitted by the officer in charge for the future improvement of this harbor, by excavating a channel through the rock forming the bed of the river, thus forming an inside instead of an outside harbor, as originally contemplated. The board, having had a thorough examination made by drilling, blasting, and dredging the rock, reported in favor of the plan, and, it being approved by the Secretary of War, operations were commenced in March and continued vigorously until May 12, when the funds became exhausted.

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The estimated cost of finishing the harbor under this project is $95,000, against $295,000 remaining unappropriated of the original estimate. The operations contemplated this season, if funds should be available, comprise superstructures over the cribs sunk last year, some repairs to the pile piers, and the continuation of the rock-excavation in the channel, which last will be done during the winter season.

Amount available July 1, 1875	$25,963 31
Amount expended during fiscal year ending June 30, 1876	25,678 40
Amount available July 1, 1876	284 91
Amount appropriated by act approved August 14, 1876	8,000 00
Amount (estimated) required for completion of existing project	95,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	25,000 00

(See Appendix W 7.)

8. *Two Rivers Harbor, Wisconsin.*—Six cribs were placed in extension of both piers, and close piling placed at the angles in the piers; dredging was done in the channel, and for beds of cribs the shore was protected at the ends of the pile piers; and one section of the south pile pier refilled. The next appropriation will be used in completing the superstructure over the cribs sunk last year, and placing four new cribs in extension of the piers. Some plank walk will also be built on the piers, and the pile piers will be repaired as far as funds will permit, by replacing the slab filling with brush, so as to make the pier more impervious to sand.

Amount available July 1, 1875	$15,627 32
Amount expended during fiscal year ending June 30, 1876	14,614 67
Amount available July 1, 1876	1,012 65
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	160,588 80
Amount that can be profitably expended in fiscal year ending June 30, 1878.	25,000 00

(See Appendix W 8.)

9. *Manitowoc Harbor, Wisconsin.*—Two cribs were placed, one in extension of each pier, and superstructure built over four cribs sunk the preceding year. Some dredging for a bed for one crib, and slight repairs to both piers, were also made. This year, as far as available funds will permit, the cribs just placed will be finished, two new cribs will be built, and some repairs, planking, and filling done on the old crib-work.

Amount available July 1, 1875	$11,556 27
Amount expended during fiscal year ending June 30, 1876	10,412 79
Amount available July 1, 1876	1,143 48
Amount appropriated by act approved August 14, 1876	8,000 00
Amount (estimated) required for completion of existing project	44,682 54
Amount that can be profitably expended in fiscal year ending June 30, 1878.	20,000 00

(See Appendix W 9.)

10. *Sheboygan Harbor, Wisconsin.*—The superstructure at this harbor is in bad condition, (some of it having been built in 1860,) and it will be removed and new timbers put on, as far as the funds will permit, the work of repair having been commenced last season, and is still in progress.

The cost has just equaled the original estimate. The decay of the superstructure, (the part above water,) and the necessity for dredging, will require an annual appropriation for some time; $6,000 is asked for the next fiscal year.

Amount available July 1, 1875	$12,502 08
Amount expended during fiscal year ending June 30, 1876	10,101 84
Amount available July 1, 1876	2,400 24
Amount appropriated by act approved August 14, 1876	6,000 00
Amount that can be profitably expended in fiscal year ending June, 30, 1878, to continue repair-work	6,000 00

(See Appendix W 10.)

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11. *Port Washington Harbor, Wisconsin.*—The channel was dredged to 10 feet water, and the west basin enlarged by dredging to 12 feet water; 24,287.22 cubic yards having been removed during the year. Repairs were also made on the revetment and the embankment on the south side of the basin.

The officer in charge recommends the excavation of the ground designed for a basin on the north side of the channel, before any further extension of the piers is made, thereby adding 100 per cent. to the size of the harbor and to its security, at an additional expense of less than 18 per cent. His estimate for the work of excavation is $27,000, which it is proposed to take from the $74,527.17 remaining unappropriated of the original estimate.

Amount available July 1, 1875	$10,992 00
Amount expended during fiscal year ending June 30, 1876	9,670 75
Amount available July 1, 1876	1,321 25
Amount appropriated by act approved August 14, 1876	8,000 00
Amount (estimated) required for completion of existing project	74,527 17
Amount that can be profitably expended in fiscal year ending June 30, 1878.	25,000 00

(See Appendix W 11.)

HARBORS OF MILWAUKEE, RACINE, AND KENOSHA, LAKE MICHIGAN—IMPROVEMENT OF FOX AND WISCONSIN RIVERS.

Officer in charge, Maj. D. C. Houston, Corps of Engineers, with Capt. G. J. Lydecker and Lieut. F. A. Hinman, Corps of Engineers, under his immediate orders.

1. *Milwaukee Harbor, Wisconsin.*—The sum of $25,000 appropriated March 3, 1875, has been applied to replacing 400 feet of the old superstructure of the north pier by one of dry stone-masonry, and in constructing 2 substantial pier-heads. The funds available will be sufficient to build 150 feet more of superstructure. The total estimate for replacing 2,240 feet of old superstructure is $120,000. Deducting the appropriations of 1875 and 1876, amounting to $51,000, there remains $69,000 which could be advantageously expended during the next fiscal year.

Amount available July 1, 1875	$24,459 16
Amount expended during fiscal year ending June 30, 1876	16,883 29
Amount available July 1, 1876, including $1,287 due on contracts	7,575 87
Amount appropriated by act approved August 14, 1876	26,000 00
Amount (estimated) required for completion of existing project	69,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	69,000 00

(See Appendix X 1.)

2. *Racine Harbor, Wisconsin.*—The appropriation of $10,000 made March 3, 1875, has been expended in dredging between the piers and in completing superstructure over crib placed in 1875.

The appropriation of $8,000 made by act of Congress, dated August 14, 1876, will be applied to rebuilding a portion of the old superstructure of the north pier. An additional amount of $7,000 is required to complete this work and building a pier-head at the extremity of the south pier.

Amount available July 1, 1875	$10,136 32
Amount expended during fiscal year ending June 30, 1876	9,891 75
Amount available July 1, 1876	244 57
Amount appropriated by act approved August 14, 1876	8,000 00
Amount (estimated) required for completion of existing project	7,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	7,000 00

(See Appendix X 2.)

3. *Kenosha Harbor, Wisconsin.*—The appropriation of $15,000 made March 3, 1875, has been expended in extending the north pier by 1 crib

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50 feet by 30 feet and in dredging the channel between the piers. The appropriation of $8,000 by the act of Congress approved August 14, 1876, will be applied to building superstructure over the two cribs placed in 1874 and 1875; in dredging between the piers, and making necessary repairs.

There is required, in addition, the sum of $7,000 to complete this work.

Amount available July 1, 1875	$15,080 88
Amount expended during fiscal year ending June 30, 1876	14,719 05
Amount available July 1, 1876	361 83
Amount appropriated by act approved August 14, 1876	8,000 00
Amount (estimated) required for completion of existing project	7,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	7,000 00

(See Appendix X 3.)

4. *Improvement of Fox and Wisconsin Rivers.*—The improvement of these rivers is being carried on in accordance with the plan heretofore reported, and the results are given in detail in the accompanying reports.

The enlargement of the Portage Canal has been completed and navigation opened, connecting the two rivers. Two new masonry-locks have been completed on the Fox, and six more will be completed this season. Five new dams will also be completed this season on the Lower Fox, and navigation be re-opened over the entire route. A large amount of dredging has been done on the Upper Fox, in deepening the channel and making cut-offs.

The improvement of the Wisconsin by means of wing-dams has been continued with satisfactory results.

Amount available July 1, 1875		$579,107 43
Amount received from tolls on Fox River for fiscal year ending June 30, 1875	$364 96	
Amount received from tolls on Fox River for fiscal year ending June 30, 1876	385 23	
		750 19
Amount expended during fiscal year ending June 30, 1876		420,415 45
Amount available July 1, 1876		159,442 17
Amount appropriated by act approved August 14, 1876		270,000 00
Amount (estimated) required for completion of existing project		2,975,663 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.		750,000 00

(See Appendix X 4.)

HARBORS OF CHICAGO, CALUMET, MICHIGAN CITY, AND NEW BUFFALO, LAKE MICHIGAN.

Officer in charge, Maj. G. L. Gillespie, Corps of Engineers.

1. *Chicago Harbor, Illinois.*—Twelve hundred and fifty running feet of superstructure were built by hired labor over the cribs sunk at the south end of the breakwater, completing this improvement to the extent of the approved plan. One thousand feet of protection were added to the north end of breakwater. Two cribs were sunk in extension of the north pier, and repairs made to north and south piers.

A survey of the harbor has also been made. Under contract, 10 cribs were sunk in extension of the north pier, making the new extension 600 feet, and, with the exception of about two full courses, for a running length of 600 feet, the superstructure is completed.

Under contract, also, the wreck of the schooner Nicaragua, lying in the outer basin, was removed and towed into deep water.

The appropriation of $5,000 for the fiscal year ending June 30, 1877,

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may be applied toward deepening the channel connecting the outer harbor with the Chicago River.

An estimate of $100,000 is submitted by the officer in charge for extending the breakwater 1,000 feet southerly; of $40,000 for excavating a channel to connect the outer harbor with the Chicago River, and of $10,000 for the repairs and preservation of existing improvements.

Amount available July 1, 1875	$110,056 64
Amount expended during fiscal year ending June 30, 1876	93,531 72
Amount available July 1, 1876, including $2,912.78 due on contracts	15,524 92
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	150,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	150,000 00

(See Appendix Y 1.)

2. *Improvement of the harbor at Calumet, Illinois.*—The south pier was extended 200 feet by contract, and by hired labor the superstructure was built over three cribs sunk last year in extension of the north pier and two cribs in extension of the south pier. A few repairs were also made to both piers.

Under contract, 33,496 cubic yards were dredged from the channel between the piers. The appropriation for the fiscal year ending June 30, 1877, may be applied toward extending the south pier 250 feet, more or less, and toward dredging 20,000 cubic yards of material from the channel.

Amount available July 1, 1875	$25,884 34
Amount expended during fiscal year ending June 30, 1876	24,077 01
Amount available July 1, 1876	1,807 33
Amount appropriated by act approved August 14, 1876	20,000 00
Amount (estimated) required for completion of existing project	49,875 52
Amount that can be profitably expended in fiscal year ending June 30, 1878	5,000 00

(See Appendix Y 2.)

3. *Improvement of the harbor at Michigan City, Indiana.*—Six hundred running feet of crib foundation have been sunk along the site of the breakwater. The east pier, to inclose the outer basin, has been completed to the shore; in all, a distance of 296 feet.

A few repairs have been made to the outer part, also to the east and west piers of the entrance to Trail Creek. The appropriation estimated as necessary to complete the breakwater, to dredge in the channel, and to make necessary repairs to existing works is $63,000.

Amount available July 1, 1875	$85,313 60
Amount expended during fiscal year ending June 30, 1876	84,122 55
Amount available July 1, 1876	1,191 05
Amount appropriated by act approved August 14, 1876	35,000 00
Amount (estimated) required for completion of existing project	63,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	63,000 00

(See Appendix Y 3.)

4. *New Buffalo Harbor, Michigan.*—No work was done at this harbor during the year, and no estimate is submitted for future improvement.

Amount available July 1, 1875	$2,279 00
Amount expended during fiscal year ending June 20, 1876	1,737 15
Amount available July 1, 1876	541 85

(See Appendix Y 4)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of March 3, 1875, Major Gillespie was charged with the examination of a route for a canal from Lake Michigan to the Wabash River, Indiana, the results of

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which were transmitted to Congress at its last session, in a report which was printed as H. R. Ex. Doc. No. 86.

(See Appendix Y 5.)

HARBORS ON THE EASTERN SHORE OF LAKE MICHIGAN.

Officer in charge, Maj. S. M. Mansfield, Corps of Engineers.

1. *Frankfort Harbor, Michigan.*—The north pier has been extended 100 feet during the year, and the superstructure over the crib sunk the previous year in extension of the south pier, together with necessary refilling, completed.

The United States dredge removed 18,195 cubic yards of sand from the channel, leaving a water-way of 11 feet between the piers.

The balance of the appropriation of 1875, together with the appropriation of $3,000 under act approved August 14, 1876, will be applied to pier-extension.

To carry out the recommendations made in yearly reports since 1872, $22,000 is required. This amount is asked for the year ending June 30, 1878.

Frankfort is an important point in the line of deep-draught vessels plying the lakes, and it is eminently desirable that it be made and preserved as a harbor of refuge.

Amount available July 1, 1875	$17,587 93
Amount expended during fiscal year ending June 30, 1876	13,185 51
Amount available July 1, 1876	4,402 42
Amount appropriated by act approved August 14, 1876	3,000 00
Amount (estimated) required for completion of existing project	22,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	22,000 00

(See Appendix Z 1.)

2. *Manistee Harbor, Michigan.*—During the year each pier has been extended 150 feet. About 450 feet of the south pier will be leveled to the required height this season. Estimated cost, $1,200.

The appropriation of $14,000 under act approved August 14, 1876, together with the funds remaining of the appropriation of 1875, will be applied to the construction of north side revetment 320 feet farther east, and in dredging channel to 12 feet of water.

A further extension of the piers is demanded at this place, and to continue improvements $30,000 is asked for the year ending June 30, 1878.

Amount available July 1, 1875	$30,736 80
Amount expended during fiscal year ending June 30, 1876	20,355 02
Amount available July 1, 1876, including $1,654.97 due on contracts	10,381 78
Amount appropriated by act approved August 14, 1876	14,000 00
Amount (estimated) required for completion of existing project	76,771 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	30,000 00

(See Appendix Z 2.)

3. *Ludington Harbor, Michigan.*—The north pier has been extended 100 feet during the year, and slight repairs in the way of refilling and protecting the south pier-head made.

The Government dredge has cleared the channel, so that there is now a water-way of 14 feet through its center.

The recommendations of last year for pier-extension are renewed, and the estimate of $36,000, less the $10,000 appropriated by act of August 14, 1876, can be profitably expended during the year ending June 30, 1878.

Amount available July 1, 1875	$15,983 43
Amount expended during fiscal year ending June 30, 1876	13,946 40

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Amount available July 1, 1876	$2,037 03
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	26,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	26,000 00

(See Appendix Z 3.)

4. *Pentwater Harbor, Michigan.*—No appropriation has been made for this harbor since 1873.

Nothing has been done here but to repair some slight damages caused by collisions of steamers with the piers.

The Government dredge will remove, this season, a bar that has formed between the piers, and the revetment alongside will be improved against further shoaling.

The recommendations and estimates of last year are renewed, viz: To dredge away old slab-revetment and substitute a pile-revetment, and to extend the north pier 150 feet, at an estimated cost of $39,200.

Amount available July 1, 1875	$1,916 89
Amount expended during fiscal year ending June 30, 1876	213 26
Amount available July 1, 1876	1,703 63
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	39,200 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	39,200 00

(See Appendix Z 4.)

5. *White River Harbor, Michigan.*—The south pier has been extended 150 feet during the year, while a portion of the old work has been sheathed and partly refilled and reballasted.

This harbor is in an unsatisfactory condition, and again needs dredging, and the old revetments require a thorough overhauling.

To carry out the permanent improvements suggested in former years requires an appropriation of $34,526.60, which amount can be profitably expended in the year ending June 30, 1878.

Amount available July 1, 1875	$17,076 12
Amount expended during fiscal year ending June 30, 1876	14,995 66
Amount available July 1, 1876	2,080 46
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	34,526 60
Amount that can be profitably expended in fiscal year ending June 30, 1878.	34,500 00

(See Appendix Z 5.)

6. *Muskegon Harbor, Michigan.*—The south pier has been extended 150 feet during the year. Some repairs will be put upon the piers this season, at an estimated cost of $1,000.

To complete the pier-extension, as recommended in the yearly report of 1873, there remains a balance of the estimate as yet unappropriated of $6,000; to this should be added $1,898.04, which was expended in 1874 on the north pier revetment, and $1,000 for repairs in progress, making a total of $8,898.04 to be appropriated for expenditure in the year ending June 30, 1878.

Amount available July 1, 1875	$27,601 11
Amount expended during fiscal year ending June 30, 1876	21,072 49
Amount available July 1, 1876	6,528 62
Amount appropriated by act approved August 14, 1876	15,000 00
Amount (estimated) required for completion of existing project	8,898 04
Amount that can be profitably expended in fiscal year ending June 30, 1878.	8,990 00

(See Appendix Z 6.)

7. *Grand Haven Harbor, Michigan.*—The work remaining unfinished at date of last report was completed by October 2, and some slight repairs added to the old work.

The exceptionally rough northwest weather last fall caused a bad bar

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to form across and between the pier-heads. This was removed in December, and no trouble has since been experienced from this cause.

In the absence of the usual ice-barriers, the past winter was a severe one, and the piers suffered damage, but not to a great extent. Repairs will be made, at an estimated expense of $858, before another winter.

To make the extension of the north pier, as recommended in my last report, the estimate of $32,000, less $15,000 recently appropriated, is renewed; also, $14,400 for revetment in bend of river; and $2,000 for repairs. Total, including contingencies and superintendence, $38,000, for the fiscal year ending June 30, 1878.

Amount available July 1, 1875	$25,346 24
Amount expended during fiscal year ending June 30, 1876	20,572 01
Amount available July 1, 1876	4,774 23
Amount appropriated by act approved August 14, 1876	15,000 00
Amount (estimated) required for completion of existing project	38,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	38,000 00

(See Appendix Z 7.)

8. *Black Lake Harbor, Michigan.*—During the year the north pier has been extended 100 feet and the south pier 50 feet. The depth of water is about the same as last year.

It is proposed to use the funds available in extending the south pier, renewing old work which has become entirely useless, and in overhauling and refilling of revetment, as well as dredging the channel.

For the year ending June 30, 1878, $15,000 can be expended to advantage.

Amount available July 1, 1875	$21,494 03
Amount expended during fiscal year ending June 30, 1876	17,212 38
Amount available July 1, 1876	4,281 65
Amount appropriated by act approved August 14, 1876	15,000 00
Amount (estimated) required for completion of existing project	15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	15,000 00

(See Appendix Z 8.)

9. *Saugatuck Harbor, Michigan.*—Work here in progress at date of last report was completed by the end of August.

A board of engineer officers examined this harbor in the spring, and in consequence of their report, the extension of the north pier was abandoned, and available funds were applied to replacing the revetment in the bend of the river, which had been undermined by the spring-freshets. This work was completed during the season.

The $3,000 appropriated in act approved August 14, 1876, is to be applied to the work of protecting the existing piers.

Ten thousand dollars is asked for pier-extension during the year ending June 30, 1878.

Amount available July 1, 1875	$17,622 92
Amount expended during fiscal year ending June 30, 1876	17,360 06
Amount available July 1, 1876	262 86
Amount appropriated by act approved August 14, 1876	3,000 00
Amount (estimated) required for completion of existing project	38,458 74
Amount that can be profitably expended in fiscal year ending June 30, 1878.	10,000 00

(See Appendix Z 9.)

10. *South Haven Harbor, Michigan.*—Five hundred and twenty-five feet of pile-revetment were added during the year on the north side.

Under the appropriation of $10,000 for this fiscal year, (1877,) it was intended to continue this revetment about 200 feet farther east and level the pier-heads, which have settled badly.

For the year 1878, it is desired to finish the work of revetting the north side, which will embrace 250 feet, at an estimated cost of $12,000.

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The extension of both piers is again recommended.

Amount available July 1, 1875	$16,219 24
Amount expended during fiscal year ending June 30, 1876	16,128 97
Amount available July 1, 1876	90 27
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	70,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	70,000 00

(See Appendix Z 10.)

11. *Saint Joseph Harbor, Michigan.*—Three hundred feet extension was made to the north pier, but the heavy weather of last March carried away the outer crib, (50 feet.)

The benefit of this work has already been thoroughly demonstrated. To complete the improvements, three cribs, (150 feet,) should be added to this pier. This work, together with needed repairs, will involve an expense of $16,261.71.

Last season, 528 feet of wing-dam were constructed in the river to deflect the current and deepen the channel to the mouth of the Benton Harbor Canal, to which was added this spring a row of piles, prolonging the dam 194 feet. The whole cost was $9,046.24.

Four thousand two hundred and seven dollars and ninety-nine cents are estimated as necessary to render the work permanent, and $7,850.56 are asked to make 800 feet of revetment above the dam to confine and utilize the water from the Paw-Paw River.

Total required—

For the harbor	$16,261 71
For the river	12,058 55
	28,320 26

less the amount ($12,000) appropriated in act approved August 14, 1876, viz, $16,320.26, the amount required for the year ending June 30, 1878.

Amount available July 1, 1875	$35,006 69
Amount expended during fiscal year ending June 30, 1876	34,641 29
Amount available July 1, 1876	365 40
Amount appropriated by act approved August 14, 1876	12,000 00
Amount (estimated) required for completion of existing project	16,320 26
Amount that can be profitably expended in fiscal year ending June 30, 1878.	16,300 00

(See Appendix Z 11.)

12. *Charlevoix Harbor, Michigan.*—To comply with a resolution of the Senate of January 6, 1876, directing—

the Secretary of War to report to the Senate upon the importance of improving the harbor at Charlevoix, in the State of Michigan, and to transmit a revised estimate of the amount necessary to complete the same—

Major Mansfield was instructed to supply the required information. This was transmitted to the Senate at its last session in a report which was printed as Senate Ex. Doc. No. 16.

(See Appendix Z 12.)

ENLARGEMENT OF SAINT MARY'S FALLS CANAL AND IMPROVEMENT OF SAINT MARY'S RIVER—HARBORS AND RIVERS ON LAKES HURON AND SAINT CLAIR—SAINT CLAIR FLATS CANAL, AND IMPROVEMENT OF DETROIT RIVER.

Officer in charge, Maj. G. Weitzel, Corps of Engineers, with Capt. A. N. Lee, Corps of Engineers, under his immediate orders.

1. *Saint Mary's Falls Canal.*—The contract of February 9, 1871, for deepening and widening the head of the canal, has been completed, as

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also the contract of May 19, 1873, for excavating pit and laying foundation-floor for the new locks, and the contract of May 22, 1875, for constructing about 400 feet of the pier on the south side of and below the proposed new locks and the excavation incident thereto.

As all of the money now available is needed to make payment under existing contracts, the officer in charge reports that the sum of $300,000 will be required for this work for the fiscal year ending June 30, 1878.

Amount available July 1, 1875	$602,996 45
Amount expended during fiscal year ending June 30, 1876	205,768 52
Amount available July 1, 1876	397,227 93
Amount appropriated by act approved August 14, 1876	130,000 00
Amount (estimated) required for completion of existing project	570,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	300,000 00

(See Appendix AA 1.)

2. *Cheboygan Harbor, Michigan.*—The two cuts across the bar were completed, three additional cuts were made, and the mouth of the river cleared as far up as where the center line of the channel cuts the line of the wharves. The narrowest part of the new channel across the bar is now 130 feet wide.

The sum of $35,000 is needed for this work for the fiscal year ending June 30, 1878.

Amount available July 1, 1875	$22,784 14
Amount expended during fiscal year ending June 30, 1876	22,521 70
Amount available July 1, 1876	262 44
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	45,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	35,000 00

(See Appendix AA 2.)

3. *Au Sable River Harbor, Lake Huron, Michigan.*—Nothing has been done on this work during the year.

An appropriation of $2,500 is needed for keeping existing works in repair during the fiscal year ending June 30, 1878.

Amount available July 1, 1875	$1,657 92
Amount expended during fiscal year ending June 30, 1876	231 30
Amount available July 1, 1876	1,426 62
Amount appropriated by act approved August 14, 1876	1,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	2,500 00

(See Appendix AA 3.)

4. *Saginaw River, Michigan.*—During the past year 2,255 linear feet of pile revetment have been built and 33,643 cubic yards of material dredged at Carrolton Bar. As it appears from the work already done at Carrolton Bar that more extensive works will be required and that two other bars lower down the river also require improvement, an estimate of $51,900 is submitted by the officer in charge for the fiscal year ending June 30, 1878, of which $12,800 is for the further improvement of Carrolton Bar, $22,400 for the improvement of Zilwaukee Bar, and $12,000 for New York Works Bar.

Amount available July 1, 1875	$34,934 97
Amount expended during fiscal year ending June 30, 1876	33,750 84
Amount available July 1, 1876	1,184 13
Amount appropriated by act approved August 14, 1876	11,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	51,900 00

(See Appendix AA 4.)

5. *Sebawaing River, Michigan.*—A channel 100 feet wide and 6 feet deep was dredged from near the mouth of the river to the 6-foot curve in Saginaw Bay, a distance of about 2,000 feet, and the Sebawaing River itself was deepened and straightened near its mouth.

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This comprised all the work that was to be done. No further appropriation is required.

Amount available July 1, 1875	$8,000 00
Amount expended during fiscal year ending June 30, 1876	8,000 00

(See Appendix AA 5.)

6. *Harbor of Refuge, Lake Huron, Michigan.*—During the past year the whole of the breakwater west of the opening in the north arm, 1,500 feet long, has been completed. The inshore end of this extends to 5½ feet of water, about 800 feet from shore. To the eastward of the opening, on the north and east arm, 1,570 feet of breakwater has been finished, completing altogether 3,070 feet of the breakwater. In addition, 4 new cribs, 65 feet long, are in place to form a continuation of the east arm of the breakwater.

The amount required for this work during the fiscal year ending June 30, 1878, is $200,000.

Amount available July 1, 1875	$276,667 56
Amount expended during fiscal year ending June 30, 1876	179,968 82
Amount available July 1, 1876	96,698 74
Amount appropriated by act approved August 14, 1876	75,000 00
Amount (estimated) required for completion of existing project	917,550 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	200,000 00

(See Appendix AA 6.)

7. *Saint Clair River, at the mouth of Black River, Michigan.*—During the year, about 67,000 cubic yards have been dredged from the middle ground by the contractors under the appropriations made by the acts approved June 23, 1874, and March 3, 1875. No further appropriation is required for this work.

Amount available July 1, 1875	$20,257 73
Amount expended during fiscal year ending June 30, 1876	14,867 21
Amount available July 1, 1876, including $368.88 due on contracts	5,390 52

(See Appendix AA 7.)

8. *Junction of Pine and Saint Clair Rivers, Michigan.*—The bar at the junction of Pine and Saint Clair Rivers, and a channel 100 feet wide and 12 feet deep, as far up Pine River as the appropriation would admit, were dredged. This completed the work. No further appropriation is required for this work.

Amount available July 1, 1875	$5,000
Amount expended during fiscal year ending June 30, 1876	5,000

(See Appendix AA 8.)

9. *Saint Clair Flats Ship-Canal.*—The existing works have been kept in repair, and about 2,800 additional willow-cuttings have been planted on the piers. No additional appropriation is required.

Amount available July 1, 1875	$15,016 22
Amount expended during fiscal year ending June 30, 1876	3,808 08
Amount available July 1, 1876	11,208 14

(See Appendix AA 9.)

10. *Improvement of Detroit River, Michigan.*—Nothing has been done on this work during the past fiscal year, except to make preparations to receive bids for work to the amount of the available means.

As no reply has been received from the Canadian government that it unite with us in the removal of the obstructions at the Lime-kilns, the officer in charge was instructed to limit his operations during the present season to our waters, as far as to expend the balance of appropriation remaining available.

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The estimate of the officer in charge for the year ending June 30, 1878, should Congress see fit to direct the continuation of the work, is $200,000. But little will result to the commerce of the lakes unless the work is carried to completion.

Amount available July 1, 1875	$21,750 93
Amount expended during fiscal year ending June 30, 1876	304 83
Amount available July 1, 1876	21,446 10
Amount that can be profitably expended in fiscal year ending June 30, 1878	200,000 00

(See Appendix AA 10.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of March 3, 1875, Major Weitzel was instructed to make the following:

1. *Estimate of cost to obtain 13 feet water on outer bar at the mouth of Saginaw River, Michigan.*—(See Appendix AA 11.)

2. *Survey of Thunder Bay River, Michigan.*—(See Appendix AA 12.)

3. *Examination of Clinton River, from Mount Clemens to its mouth, Michigan.*—(See Appendix AA 13.)

4. *Examination for a breakwater off the mouth of Au Sable River, Michigan.*—(See Appendix AA 14.)

These reports were submitted to Congress at its last session, and printed in H. R. Ex. Doc. No. 121.

HARBORS ON LAKE ERIE.

Officer in charge, Lieut. Col. C. E. Blunt, Corps of Engineers, with Capt. M. B. Adams, Corps of Engineers, under his immediate orders.

1. *Monroe Harbor, Michigan.*—The work during the year has been confined to dredging on the shoal near the entrance to the harbor, and in repairs of the piers. Eighteen thousand five hundred and sixteen yards of sand were removed.

Three thousand two hundred and sixty feet of the decayed canal revetments still need renewal, and additional pier repairs will probably be necessary.

Amount available July 1, 1875	$8,734 45
Amount expended during fiscal year ending June 30, 1876	8,693 91
Amount available July 1, 1876	40 54
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	11,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	11,000 00

(See Appendix BB 1.)

2. *Toledo Harbor, Ohio.*—The work of dredging in the channel has been carried on during the year in accordance with the plan of the board of engineer officers approved in January, 1873. Two hundred and forty-three thousand two hundred and fifteen cubic yards of material have been removed by dredging.

To complete the work $140,000 will be required, and this amount is asked for the next fiscal year.

Amount available July 1, 1875	$85,514 05
Amount expended during fiscal year ending June 30, 1876	81,333 38
Amount available July 1, 1876	4,180 67
Amount appropriated by act approved August 14, 1876	60,000 00
Amount (estimated) required for completion of existing project	140,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	140,000 00

(See Appendix BB 2.)

3. *Port Clinton Harbor, Ohio.*—Nothing has been done here during the year, for want of funds. The effect of last year's experimental construc-

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tion has been very satisfactory. The small sum again appropriated this summer will be expended mainly in commencing an east pier or bulkhead in continuance of the suggested plan. Should additional funds be granted, it is proposed to continue the construction of the works intended to deepen the channel by confining the river current.

Amount available July 1, 1875	$293 35
Amount expended during fiscal year ending June 30, 1876	277 15
Amount available July 1, 1876	16 20
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	112,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	20,000 00

(See Appendix BB 3.)

4. *Sandusky City Harbor, Ohio.*—During the year the cut through the outer bar has been essentially completed. The quantity of material dredged and removed was 89,561 cubic yards.

The channel, originally intended to terminate at the 12-foot curve, should be continued toward the town, from which the present terminus is over a mile distant. The extension will cost $50,000, and the completion of the original project $55,000; in all, for the amended project, $105,000; $55,000 is asked as the next appropriation.

Amount available July 1, 1875	$35,022 04
Amount expended during the fiscal year ending June 30, 1876	34,915 27
Amount available July 1, 1876	106 77
Amount appropriated by act approved August 14, 1876	25,000 00
Amount (estimated) required for completion of existing project	105,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	55,000 00

(See Appendix BB 4.)

5. *Huron Harbor, Ohio.*—The greater part of the appropriation of $1,000 made by act of March 3, 1875, with a small balance of a preceding appropriation, was expended during the latter part of the season of 1875 in minor repairs of the west pier.

The harbor is in good condition and no further appropriation is asked for, the balance on hand being probably sufficient for small repairs that may be needed during the coming year.

Amount available July 1, 1875	$1,816 45
Amount expended during fiscal year ending June 30, 1876	1,627 28
Amount available July 1, 1876	189 17

(See Appendix BB 5.)

6. *Vermillion Harbor, Ohio.*—The appropriation of $10,000 by act of March 3, 1875, was expended in the fall of that year in widening and deepening the channel. To complete this and make some further pier-repairs, an estimate of $9,000 is made.

Amount available July 1, 1875	$10,000 00
Amount expended during fiscal year ending June 30, 1876	9,874 55
Amount available July 1, 1876	125 45
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	9,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	9,000 00

(See Appendix BB 6.)

7. *Black River Harbor, Ohio.*—The extension of the east pier, in progress at the date of the last annual report, has been completed. Both piers have now reached their proposed lake terminus. The channel-dredging reported necessary last year has been done. Injuries to both piers and to the shore-line were caused by a severe gale in May, 1876. The balance on hand was sufficient to thoroughly repair the west, or light-house pier. The appropriation of August 14, 1876, will be sufficient to complete these repairs and protect the shore-line.

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Amount available July 1, 1875	$15,704 84
Amount expended during fiscal year ending June 30, 1876	15,648 43
Amount available July 1, 1876	56 41
Amount appropriated by act approved August 14, 1876	6,000 00

(See Appendix BB 7.)

8. *Rocky River Harbor, Ohio.*—The pier, previously 648 feet long, has been extended 180 feet during the past fiscal year. The channel has also been deepened by the removal of 31,820 cubic yards of material.

No additional appropriation is required.

Amount available July 1, 1875	$15,000 00
Amount expended during fiscal year ending June 30, 1876	15,000 00

(See Appendix BB 8.)

9. *Cleveland Harbor, Ohio.*—The construction of the new breakwater for this harbor, (estimated to cost $1,800,000,) for the commencement of which $50,000 was appropriated March 3, 1875, was begun last winter. Up to June 30, 333 running feet of the shore end was completed. The work is still in progress, the contract expiring November 30, 1876.

For further continuance an appropriation of $200,000 is asked.

Amount available July 1, 1875	$58,426 98
Amount expended during fiscal year ending June 30, 1876	25,000 72
Amount available July 1, 1876, including $971.60 due on contracts	33,426 26
Amount appropriated by act approved August 14, 1876	50,000 00
Amount (estimated) required for completion of existing project	1,700,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	200,000 00

(See Appendix BB 9.)

10. *Grand River Harbor, Fairport, Ohio.*—The west pier was extended 136 feet last year, and for the present no further extension of either pier is proposed. The east pier is now 104 feet shorter than the west, and it may be found necessary to make the two of equal length.

Repairs of the inner portion of the old west pier will be made with the appropriation of August 14, 1876.

Amount available July 1, 1875	$13,144 84
Amount expended during fiscal year ending June 30, 1876	10,723 41
Amount available July 1, 1876	2,421 43
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	3,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	3,000 00

(See Appendix BB 10.)

11. *Ashtabula Harbor, Ohio.*—The 360 feet of west pier extension reported in progress last year, has been completed. The channel has been widened to 100 feet and deepened to 14 feet, by blasting and dredging. A survey to ascertain its exact present condition is in progress.

The west pier extension will be continued with the appropriation of August 14, 1876. The possible necessity of extending the east pier is anticipated.

Amount available July 1, 1875	$37,972 86
Amount expended during fiscal year ending June 30, 1876	23,349 01
Amount available July 1, 1876, including $907.38 due on contracts	14,623 85
Amount appropriated by act approved August 14, 1876	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	15,000 00

(See Appendix BB 11.)

12. *Conneaut Harbor, Ohio.*—Some minor repairs of piers were made during the year, and the harbor is now in good condition.

No appropriation is asked for.

Amount available July 1, 1875	$1,233 45
Amount expended during fiscal year ending June 30, 1876	1,165 00
Amount available July 1, 1876	68 45

(See Appendix BB 12.)

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13. *Erie Harbor, Pennsylvania.*—Dredging in the channel and at the mouth of the harbor was continued during the fiscal year. Additions to the north pier have been made, and the inside of the north spit has been partially protected by rebuilding the superstructure of part of the old narrow inner breakwater. An addition of 3,056 feet has been made to the riprapped fence like protection of the peninsula-beach, the total length being now 4,536 feet.

A greater expenditure will be required at Erie than was anticipated at the date of last year's report, which is mainly owing to the uncertain amount of beach-protection required, and is explained in the report of the officer in charge. The amount he estimates, in addition to that now available, is $56,000.

Amount available July 1, 1875	$67,338 68
Amount expended during fiscal year ending June 30, 1876	42,327 62
Amount available July 1, 1876	25,011 06
Amount appropriated by act approved August 14, 1876	40,000 00
Amount (estimated) required for completion of existing project	56,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	56,000 00

(See Appendix BB 13.)

14. *Dunkirk Harbor, New York.*—The work done during the year has been:

1st. The building of 120 feet of breakwater superstructure left unfinished last year, and the entire completion of 210 feet new work, embracing 7 cribs. The breakwater is now 828 feet long.

2d. The removal of 4,465 cubic yards of material, mostly rock, from the channel.

The channel will be completed with the balance of last year's appropriation now on hand.

With the appropriation of $18,000, of August 14, 1876, the breakwater will be continued eastwardly. For continuing this extension an appropriation of $40,000 is asked.

Amount available July 1, 1875	$34,099 01
Amount expended during fiscal year ending June 30, 1876	21,548 27
Amount available July 1, 1876	12,550 74
Amount appropriated by act approved August 14, 1876	18,000 00
Amount (estimated) required for completion of existing project	102,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	40,000 00

(See Appendix BB 14.)

15. *Buffalo Harbor, New York.*—The results of last year's expenditure have been as follows: Extension of the completed breakwater 200 feet, (four cribs,) and the sinking and filling of a fifth crib, (50 feet;) addition of 220 feet to the pile-pier, forming the south end of the harbor; removal of about 10,000 cubic yards of sand, &c., from the shoal outside the south pier.

With the next appropriation the extension of the main breakwater will be continued.

Reports (accidentally omitted in my last annual report) from a board of engineer officers assembled at Buffalo in 1874, to take into consideration and report upon the project adopted for the improvement of Buffalo Harbor, will be found in Appendix B B 16.

Amount available July 1, 1875	$97,433 62
Amount expended during fiscal year ending June 30, 1876	97,423 58
Amount available July 1, 1876	10 04
Amount appropriated by act approved August 14, 1876	85,000 00
Amount (estimated) required for completion of existing project	1,815,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	200,000 00

(See Appendix BB 15.)

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HARBORS ON LAKE ONTARIO AND THE RIVER SAINT LAWRENCE.

Officers in charge, Maj. John M. Wilson, Corps of Engineers, to December 1, 1875, since which time Maj. Walter McFarland, Corps of Engineers.

1. *Wilson Harbor, New York.*—During the year the west pier has been extended 60 feet, the east pier 30 feet, and the channel between them has been deepened to 12 feet at ordinary low water, over a length of 800 feet and width of 200 feet.

The improvement in progress at this harbor is the extension of the piers to 12 feet water in the lake, and the dredging of a channel 1,800 feet long to the deep water of Twelve-Mile Creek.

Amount available July 1, 1875	$9,886 17
Amount expended during fiscal year ending June 20, 1876	9,719 53
Amount available July 1, 1876	166 64
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	70,000 00
Amount than can be profitably expended in fiscal year ending June 30, 1878.	20,000 00

(See Appendix CC 1.)

2. *Olcott Harbor, New York.*—The work in this harbor has been confined to widening the channel previously excavated between the piers, and to making a cut into the deep water of the creek; besides protecting the outer angles of the piers which had been damaged by the ice during the winter.

Of the $118,000 originally estimated as the cost of improving the harbor, $115,000 have already been appropriated, but to complete the project, $10,000 more are required.

Amount available July 1, 1875	$9,967 15
Amount expended during fiscal year ending June 30, 1876	6,482 95
Amount available July 1, 1876, including $3,193.89 due on contracts	3,484 20
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	10,000 00

(See Appendix CC 2.)

3. *Oak Orchard Harbor, New York.*—The small balance available for this harbor, at the beginning of the fiscal year, was applied to the removal of sandstone rock from the channel, about 200 cubic yards of which were blasted and dredged out.

Amount available July 1, 1875	$5,131 30
Amount expended during fiscal year ending June 30, 1876	4,896 66
Amount available July 1, 1876	234 64
Amount appropriated by act approved August 14, 1876	2,000 00
Amount (estimated) required for completion of existing project	4,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	4,000 00

(See Appendix CC 3.)

Charlotte Harbor, New York.—Operations at this harbor during the year have been confined to the repair of the decayed and damaged piers, and of the light-house walk which passes from the shore end of the west pier to its lake end.

Amount available July 1, 1875	$4,961 75
Amount expended during fiscal year ending June 30, 1876	4,363 89
Amount available July 1, 1876	597 86

(See Appendix CC 4.)

5. *Pultneyville Harbor, New York.*—The superstructure was built over 120 feet of cribs sunk last year, and the channel was widened to 130 feet and deepened to 10 feet, average; and a cut was made from the channel to the deep water of the creek. In accordance with estimates

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previously given, it will require an additional sum of $18,000 to carry out the proposed improvement.

Amount available July 1, 1875	$9,846 18
Amount expended during fiscal year ending June 30, 1876	9,719 62
Amount available July 1, 1876	126 56
Amount appropriated by act approved August 14, 1876	3,000 00
Amount (estimated) required for completion of existing project	18,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	18,000 00

(See Appendix CC 5.)

6. *Great Sodus Harbor, New York.*—Work at this harbor during the year was confined to the repair of the old damaged pier-work, and to the construction of a sand-catcher at the inner end of the west pier, to prevent sand from blowing into the channel.

To complete the repairs and to dredge the channel as originally proposed, will require an additional appropriation of $10,000.

Amount available July 1, 1875	$10,057 97
Amount expended during fiscal year ending June 30, 1876	7,836 85
Amount available July 1, 1876	2,221 12
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	10,000 00

(See Appendix CC 6.)

7. *Little Sodus Harbor, New York.*—The east breakwater was extended 660 feet, and 795 feet of superstructure were built over these 660 feet of cribs, and over 135 feet of cribs sunk last year.

The original estimate for the improvement of this harbor, according to the plan now in course of execution, was $176,000, of which nearly $164,000 have been already appropriated. Yet required, $12,000.

Amount available July 1, 1875	$12,553 28
Amount expended during fiscal year ending June 30, 1876	11,263 32
Amount available July 1, 1876	1,289 96
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	12,000 00

(See Appendix CC 7.)

8. *Oswego Harbor, New York.*—The crib-work of the new breakwater was extended 445 feet, making the total length so far 3,692 feet. The superstructure was built completely over 470 feet, and was completed over a length of 300 feet, which had been partly built the preceding year. Two breaches in the new breakwater, and other damages to it and to the old pier caused by the winter-storms, were repaired.

The total length of completed superstructure is now 3,482 feet, leaving 210 feet of the length of the cribs upon which the superstructure is not yet laid.

The breakwater is designed to be, when finished, 5,800 feet long.

Amount available July 1, 1875	$64,685 39
Amount expended during fiscal year ending June 30, 1876	55,626 90
Amount available July 1, 1876	9,058 49
Amount appropriated by act approved August 14, 1876	90,000 00
Amount (estimated) required for completion of existing project	557,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	300,000 00

(See Appendix CC 8.)

9. *Ogdensburgh Harbor, New York.*—The work here during the year consists entirely of dredging in channels already formed, in order to deepen and widen them. Twenty-four thousand cubic yards of material were removed.

The original estimate of the cost of the plan adopted for the improve-

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ment of this harbor was $175,000, of which $107,000 has been appropriated and expended.

The amount needed to complete the work as proposed is $70,000; but as this was to be applied to a pile-protection to the channel, the absolute necessity of which is not yet made certain, this estimate may be omitted for the present.

Amount available July 1, 1875	$4,924 38
Amount expended during fiscal year ending June 30, 1876	4,865 28
Amount available July 1, 1876	59 10
Amount (estimated) required for the completion of existing project	70,000 00

(See Appendix CC 9.)

10. *Waddington Harbor, New York.*—Work here was confined to the formation of a new channel from the old channel to the dam, the width being about 100 feet and the depth limited by the rock substratum, varying from 3½ to 9 feet.

The amount originally estimated as necessary for this improvement has been appropriated and expended, and no further appropriation is asked for.

Amount available July 1, 1875	$5,016 83
Amount expended during fiscal year ending June 30, 1876	4,974 11
Amount available July 1, 1876	42 72

(See Appendix CC 10.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of March 3, 1875, Major Wilson, Corps of Engineers, was charged with, and completed before his transfer from the charge of the harbor works on Lake Ontario, the *survey of the mouth of Sandy Creek, New York*, (see Appendix C C 11,) and also an *examination for the purpose of ascertaining the practicability and cost of constructing a canal and locks around the rapids in the Saint Lawrence River, at Waddington New York.* (See Appendix C C 12.) His reports upon the above were transmitted to Congress at its last session, and printed in H. R. Ex. Doc. No. 92.

PACIFIC COAST.

IMPROVEMENT OF OAKLAND HARBOR—CONSTRUCTION OF BREAKWATER AT WILMINGTON—REMOVAL OF RINCON ROCK, SAN FRANCISCO HARBOR, AND IMPROVEMENT OF SACRAMENTO AND FEATHER RIVERS.

Officer in charge, Maj. G. H. Mendell, Corps of Engineers, with Lieut. C. B. Sears, Corps of Engineers, under his immediate orders to September 3, 1875.

1. *Improvement of Oakland Harbor, California.*—The north training-wall is extended for a distance of 9,400 feet, and the south wall for a distance of 10,807 feet. Where the walls are exposed to the heavy waves, the height above low water is now about 2½ feet. In positions of little exposure, the height is about 4 feet. Ninety-four thousand four hundred and ninety-eight tons of stone were deposited on these walls during the year, of which 40,200 were delivered under contract and 54,298 by a temporary arrangement. The price in each case was the same, namely, $1.19 per ton of 2,240 pounds.

Twelve thousand four hundred and fifty-one yards of dredging were excavated, at a cost of 24 cents a yard.

The south crib was removed under contract for the sum of $3,000.

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A careful trigonometric and hydrographic survey of the estuary was made for future reference and in order to establish the lines of the harbor-front.

A survey and map were made of lands to be condemned for the tidal canal to connect San Antonio and San Leandro estuaries. The trial for condemnation is soon to take place.

The operations of the coming year will consist in dredging, for which a contract has been made, and in continuing the training-walls.

Amount available July 1, 1875	$179,135 67
Amount expended during fiscal year ending June 30, 1876	131,978 17
Amount available July 1, 1876	47,157 50
Amount appropriated by act approved August 14, 1876	45,000 00
Amount (estimated) required for completion of existing project	1,614,529 20
Amount that can be profitably expended in fiscal year ending June 30, 1878.	250,000 00

(See Appendix DD 1.)

Improvement of Wilmington Harbor, California.—During the year the contractor has excavated from the channel 6,467 yards of stone, 3,557 yards of clay, and 11,864 yards of sand. The dredging-operations were suspended from December to March 15. The exposure is so great in the winter, that work of this kind cannot be carried on successfully.

Most of the stone and clay was used in the extension of dike No. 2, which was extended 280 feet to make a part of a training-wall, intended to bound the channel on the west.

Thirty-six hundred and ten tons of stone were used during the year for covering the timber-work and in filling short cribs of timber placed along the line to collect the sand.

The condition of the channel improves slowly but steadily. There is now a depth of 7 feet at mean low water throughout the length of the entrance, except for a distance of about 150 feet, over which interval the depth is a small fraction of a foot less. The channel widens and straightens under the action of its own natural causes. The sand collects slowly on the inside of the work, but each year shows a decided improvement.

The operations of the coming year will be, as far as funds available will admit, dredging a channel 100 feet wide and 14 feet deep through the reef, in the construction of the training-wall before mentioned, and in raising the stone portion of the main jetty next Deadman's Island to the height of spring-tides.

Two hydrographic surveys were made in the past year; in addition, the lower part of the estuary was surveyed trigonometrically.

Amount available July 1, 1875	$82,066 24
Amount expended during fiscal year ending June 30, 1876	41,798 09
Amount available July 1, 1876, including $4,016.55 due on contracts	40,268 15
Amount (estimated) required for completion of existing project	100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	100,000 00

(See Appendix DD 2.)

3. *Improvement of San Francisco Harbor, California.—Removal of Rincon Rock.*—No work was done in the removal of Rincon Rock from June, 1875, to May, 1876, since which one of the sureties of the contractor has been as steadily at work as the proximity of wharves and shipping will safely permit. At the date of the last report it was estimated that about 516 yards remained to be removed. No survey has since been made.

The explanation of the long suspension of the work is that the contractor was enjoined by a State court, at the suit of a creditor, from receiving any payments from the United States, and without such pay-

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ments he was unable to carry on the work. The work will be completed in the course of the present fiscal year.

Amount available July 1, 1875	$24,572 69
Amount expended during fiscal year ending June 30, 1876	192 42
Amount available July 1, 1876, including $20,657.21 due on contracts	24,380 27

(See Appendix DD 3.)

4. *Improvement of Sacramento and Feather Rivers, California.*—One hundred and eighty snags were removed from the Sacramento River, between Grimes Landing and Walsh's Landing, a distance of 115 miles.

On the Feather River 1,820 linear feet of brush-dams were built, distributed between 3 shoal places, namely: Marysville Rapids, Suttee Ranch, and Whisky Chute. Twenty-four snags were removed from the Feather River.

The effect on the Sacramento River was to give an available channel of 3½ feet depth as high as Jacinto, and 2½ to Walsh's Landing. This improvement was of great value to the farmers along the river, who send by this route large agricultural products.

The Feather River was also improved so that the boat to Marysville was able to pass the shoalest places easily.

Amount available July 1, 1875	$14,982 66
Amount expended during fiscal year ending June 30, 1876	14,722 78
Amount available July 1, 1876	259 88
Amount that can be profitably expended in fiscal year ending June 30, 1878	20,000 00

(See Appendix DD 4.)

IMPROVEMENT OF THE HARBOR OF SAN DIEGO, CALIFORNIA.

Officer in charge, Lieut. Col. C. S. Stewart, Corps of Engineers, with Lieut. J. H. Weeden, Corps of Engineers, under his immediate orders.

1. *San Diego Harbor, California.*—During the fiscal year a project for this work was formed by the majority of the Board of Engineers for the Pacific Coast, and approved by the Secretary of War. The new survey, maps, descriptions of land, &c., required for procuring the right of way were then made, and proceedings instituted in the proper court, by the United States attorney for California, for condemnation of the land needed for public use. As the result, on May 29, 1876, the title to the land was vested in the United States. Contracts having in the meantime been made for earth and stone work, under them ground was broken on June 5.

At the end of the fiscal year a portion of the channel had been excavated in part, and corresponding embankment of the levee made for a length of 890 feet from its western terminus, and 350 feet of levee built from the eastern end; the latter length had also been faced with stone.

Total earth excavated and put in place under the contract, 4,365 cubic yards. Total stone in place, 434 cubic yards.

Amount available July 1, 1875	$78,330 74
Amount expended during fiscal year ending June 30, 1876	4,185 72
Amount available July 1, 1876	74,145 02

(See Appendix EE 1.)

IMPROVEMENT OF RIVERS IN OREGON AND WASHINGTON TERRITORY.

Officers in charge, Maj. N. Michler, Corps of Engineers, to December 28, 1875, since which time Maj. John M. Wilson, Corps of Engineers.

1. *Improvement of the Lower Willamette and Columbia Rivers.*—Operations during the fiscal year have consisted of dredging at Post-office Bar

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and the bar at the mouth of the Willamette, and at Saint Helen's bar, in the Columbia River. Surveys have been made of these various bars, of the shore-line at Sand Island, and of the bar at the mouth of the Columbia.

Extensive repairs have been made to the United States dredge and scows.

During the present season it is proposed, whenever the freshet will admit, to continue dredging the bars at Swan Island, Post-office, mouth of the Willamette, and at Saint Helen's, in the Columbia, and to make new surveys of those bars. An additional dredge is required.

The proposed project of the officer now in charge for the permanent improvement of the Willamette and Columbia Rivers from Portland to the sea (see Appendix F F 10) has been referred to the Board of Engineers for the Pacific Coast for opinion thereon.

Amount available July 1, 1875	$26,625 74
Amount expended during fiscal year ending June 30, 1876	17,532 50
Amount available July 1, 1876	9,093 24
Amount appropriated by act approved August 14, 1876	20,000 00
Amount (estimated) required for completion of proposed project	328,526 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	150,000 00

(See Appendixes FF 1 and FF 10.)

2. *Improvement of the Upper Willamette River, Oregon.*—Operations during the fiscal year have consisted of the removal of snags, stumps, rocks, &c., the construction of wing-dams, and the survey of portions of the river.

The United States snag-boat has removed 707 snags, stumps, &c., and 12¼ yards of rock; wing-dams have been constructed at Union and Lone Tree bars, aggregating 1,530 feet in length. Surveys have been made from Eugene City to Ingram's Bend, from Albany to Salem, and of various bars between Salem and Oregon City, aggregating in all a distance of 66 miles.

During the present season it is proposed to continue operations with the snag-boat, to construct about 3,100 feet of wing-dam, to elevate 75 cubic yards of rock, and to make a survey of the river from Salem to Portland.

Amount available July 1, 1875	$25,000 00
Amount expended during fiscal year ending June 30, 1876	16,961 75
Amount available July 1, 1876, including $275.40 due on contracts.	8,038 25
Amount appropriated by act approved August 14, 1876	20,000 00
Amount (estimated) required for completion of existing project	Project incomplete.
Amount that can be profitably expended in fiscal year ending June 30, 1878	45,000 00

(See Appendixes FF 2 and FF 11.)

3. *Improvement of the Upper Columbia and Snake Rivers, Oregon, Washington, and Idaho.*—Operations during the winter season of the fiscal year, the only time work can be carried on, have been in progress at Homly and Upper Umatilla Rapids, 118.36 cubic yards of rock having been removed from the former, and 367.49 cubic yards from the latter, the channel in both places having been greatly improved.

During the working season of the present fiscal year it is proposed to continue the excavation of dangerous rocks from the channel at Umatilla, Rock Creek, Owyhee, and Squally Hook Rapids, in the Columbia River, and from Pine-Tree Rapid, in the Snake River.

Amount available July 1, 1875	$35,644 51
Amount expended during fiscal year ending June 30, 1876	19,637 41
Amount available July 1, 1876, including $2,291.90 due on contracts.	16,007 10

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Amount appropriated by act approved August 14, 1876	$15,000 00
Amount (estimated) required for completion of existing project	Project incomplete.
Amount that can be profitably expended in fiscal year ending June 30, 1878	30,000 00

(See Appendixes FF 3 and FF 12.)

4. *Improvement of the Umpqua River, Oregon.*—No additional work has been accomplished on this river during the fiscal year, and no further work is proposed.

There is a balance of $4,685.89 remaining from the appropriation of March 3, 1871.

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Michler was charged with and submitted to this office reports upon the following, for which provision was made in the river and harbor act of March 3, 1875:

1. *At mouth of Nehalem River, Oregon.*—(See Appendix F F 6.)

2. *Puyallup River, from the coal-mines to its mouth, Washington Territory.*—(See Appendix FF 7.)

3. *For canal to connect Shoalwater Bay with the Columbia River.*—(See Appendix FF 8.)

4. *Alsea River and Bar, Oregon.*—(See Appendix FF 9.)

Major Wilson has also, under instructions from this office, submitted reports upon the Puyallup River and the canal route from Shoalwater Bay to Columbia River. (See Appendixes FF 13, and FF 14.)

IMPROVEMENT AND CARE OF PUBLIC BUILDINGS AND GROUNDS IN THE DISTRICT OF COLUMBIA—WASHINGTON AQUEDUCT.

Officer in charge, Col. O. E. Babcock, Corps of Engineers.

The condition of the public reservations in the city of Washington, and of the aqueduct for supplying the cities of Washington and Georgetown with water, and the character of the improvements made on them during the fiscal year, will be found in the detailed report of the officer in charge.

The estimates of the officer in charge for the fiscal year ending June 30, 1878, as revised in this office, are as follows:

For improvement and care of public buildings and grounds	$229,050
For compensation to persons employed on and around public buildings and grounds	46,980
For contingent and incidental expenses	2,000
	278,030
For the Washington Aqueduct	349,500

(See Appendix GG.)

SURVEYS AND EXAMINATIONS WITH A VIEW TO THE IMPROVEMENT OF RIVERS AND HARBORS.

For examinations and surveys of rivers and harbors and for incidental repairs of harbors, for which there is no special appropriation, an appropriation of $150,000 should be made.

SURVEY OF NORTHERN AND NORTHWESTERN LAKES.

Officer in charge, Maj. C. B. Comstock, Corps of Engineers, who has under his immediate orders the following officers of the Corps of Engi-

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neers: Capt. H. M. Adams, First Lieuts. D. W. Lockwood, C. F. Powell, P. M. Price, and Second Lieut. T. N. Bailey; and the following principal assistants engineers: O. B. Wheeler, E. S. Wheeler, G. Y. Wisner, A. R. Flint, G. A. Marr, J. R. Mayer, A. C. Lamson, F. M. Towar, R. S. Woodward, T. W. Wright, Frederick Terry, and Thomas Russell.

Progress of the work during the year.—The triangulation, topography, and hydrography of Lake Ontario have been carried from Olcott west to the Welland Canal, completing the field-work.

The survey of the Niagara River has been completed.

On Lake Erie, the triangulation has been carried west to Westfield. The topography and hydrography have been carried on the north shore, west, to the Welland Canal, and on the south shore, west, to Ashtabula.

Stations have been erected east from Michigan City as far as Mongo, for connecting the triangulations of Lakes Michigan and Erie.

Lines of levels have been run from Albany to Oswego and from Port Dalhousie to Port Colborne.

Determinations of latitude and longitude have been made at 10 points in aid of State surveys.

A chart of south end of Lake Michigan, charts Nos. 3, 4, and 5 of the Saint Lawrence River, and a chart of Sand Beach Harbor of Refuge, Lake Huron, have been completed during the year.

During the coming year, should the appropriation be only $100,000 for both the lakes and the Mississippi River, it is hoped to carry the work on Lake Erie west to the vicinity of Sandusky, and to read the angles at the stations already erected east of Michigan City.

During the last and the preceding fiscal years there have been received at the War Department, through the Department of State, a series of papers containing much valuable information respecting the methods adopted by the military establishments of various European governments in carrying on their great national surveys. These papers have been sent from time to time to Major Comstock, (at whose request they were obtained,) who has had them translated. He has also compiled extracts of these papers, which will, no doubt, be found useful in the prosecution of the public surveys of the United States.

Amount expended during fiscal year 1875–'76	$137,571 13
Amount available for fiscal year 1876–'77	100,000 00
Amount required for survey of northern and northwestern lakes and Mississippi River, for fiscal year ending June 30, 1878, namely, for continuing survey of Lake Erie, for determination of points in aid of State surveys and construction of maps, for continuation of triangulation south from Chicago and east to connect with Lake Erie, for the survey of the Mississippi River, and miscellaneous	212,000 00

(See Appendix HH.)

MILITARY, GEOGRAPHICAL, AND LAKE-SURVEY MAPS.

The preparation and engraving of the sheets to exhibit the positions of the troops of the opposing armies on the 1st, 2d, and 3d of July, 1863, at Gettysburg, is nearly complete, and will soon be ready for distribution. It was expected to have them ready during the fiscal year just closed, but the work had to be deferred to keep open the opportunity to add valuable information whose sources have only recently been reached.

In this office:

Of the series of Atlanta campaign maps, sheets 1 and 3 have been

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completed and printed, and on sheets 2 and 5 considerable progress has been made.

The map of the siege of Atlanta, on a scale of 2 inches to the mile, has been completed and is now in the hands of the photolithographer.

The map of the battle-field of Chickamauga still remains in an unfinished state, proofs having been submitted to the officers commanding divisions and brigades for their examination and correction.

A map of the marches of the forces under command of General Sherman in 1863,-'64,-'65; also, maps of the battle-fields of Franklin, Tennessee, and South Mountain, Maryland, have been reproduced by photolithography to replace the editions of these maps which were accidentally destroyed by fire in this office in February, 1875.

The following maps, illustrating the operations of the late war, have been photolithographed and printed:

Map of battle of Roanoke Island.
Map of battle of Drainsville.
Map of the operations of the Army of Virginia under General Pope.
Plan of Fort Donaldson and outworks.
Map of the country between Forts Henry and Donelson.
Plan of Fort Henry.
Map of Port Hudson and vicinity.
Map of the siege operation at Spanish Fort, Mobile Bay.
Map of the country between Miliken's Bend and Jackson, Mississippi.
Map of the battle-field of Pea Ridge, Arkansas.
Map of the battle-field of Big Black River Bridge, Mississippi.
Map of the battle-field of Iuka, Mississippi.
Map of the battle-field of Island No. 10 and New Madrid.
Map of the battle-field of Belmont, Missouri.
Map of the battle-field of Carnifex Ferry, Virginia.

A map of the territory of the United States west of the Mississippi River, on a scale of 1:500,000, has been commenced.

The military map of the United States, published by this Department, has been revised and is now in the hands of the engraver.

A large map of the United States, on a scale of 1 inch to 16 miles, has been prepared and forwarded to the Centennial Exposition, at Philadelphia.

Thirty-two maps illustrating a reconnaissance of the Mississippi River from Cairo to New Orleans have been photolithographed and printed.

Sheets 1 and 3, Department of Arizona, by Lieut. J. C. Mallery, Corps of Engineers, have been photolithographed and printed.

Sheet No. 3 of the map of the Western Territory, by Maj. G. L. Gillespie, has been photolithographed and printed.

A map showing the lines of communication in Southern Colorado and New Mexico, by Lieut. E. H. Ruffner, Corps of Engineers, has been photolithographed and printed.

A map of a reconnaissance from Carroll, Montana, to the Yellowstone National Park, and a map of Judith Basin and of the Geyser Basin, by Capt. William Ludlow, Corps of Engineers, have been photolithographed and printed.

A map of the Yellowstone and Missouri Rivers and their tributaries, with corrections and additions made under the direction of Maj. G. L. Gillespie, is now in the hands of the engraver.

Lake survey charts Nos. 1, 2, and 3 of the Saint Lawrence River have been engraved on copper, and an edition of each has been printed. Chart No. 4 has been photolithographed and an edition printed for a preliminary in advance of the engraved edition. This chart is now in

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the hands of the engraver. Chart No. 5 is in the hands of the photolithographer for a preliminary edition before engraving.

A lake-survey chart of the south end of Lake Michigan has been completed and is now in the hands of the photolithographer in order that a preliminary edition may be printed.

A lake-survey chart of Harbor of Refuge at Sand Beach, Lake Huron, has been photolitographed, and an edition printed in advance of the engraved edition. The chart is now in the hands of the engraver.

A lake-survey chart of Niagara Falls has been photolithographed and printed.

Lake Michigan coast chart No. 5 has been completed, and is now being photolithographed for a preliminary edition, after which the chart will be engraved.

GEOLOGICAL EXPLORATION OF FORTIETH PARALLEL.

Mr. Clarence King, United States civil engineer, in charge.

During the year Mr. King and his assistants have been in office engaged upon the final preparation of his report with its illustrations and atlas. It was intended that volume IV should consist of reports on microscopic petrography by Dr. Ferdinand Zirkel, on Invertebrate paleontology by F. B. Meek, on paleozoic mollusks by Messrs. Hall and Whitfield, and on the zoological observations made during the survey by Robert Ridgway, which would make altogether a quarto volume of about 900 pages of print, but for convenience it has been determined, at the instance of Mr. King, to print the reports of Messrs. Meek, Hall, and Whitfield and Ridgway in volume IV, leaving the report on petrography by Dr. Zirkel for a separate volume to be numbered VI. Volume IV is in the hands of the Public Printer; volume VI is ready for the press, and the illustrations for both have been printed. Volume II, embracing the geological results of Mr. King and of his assistants, Messrs. Emmons and Hague, has been completed with the exception of a small portion of the final chapter. The illustrations to accompany the volume have been drawn on stone, and before the printer shall have completed volume IV, volume II will be ready for the press. Volume I, embodying a general and systematic review of the results of the geological exploration of the fortieth parallel, which is necessarily the latest of the series, will be ready for the printer before he can complete the printing of volume II. The illustrations of volume I, including series of geological landscapes, geological maps and diagrams illustrating orography, are already engraved upon stone and have been printed ready for the publication of this volume.

If there are no unforseen delays the printing of the entire series of volumes, Mr. King states, will be completed by the 1st of January next.

A general atlas, embracing a general sketch-map of the mountains within the United States, and west of the 104th meridian, 10 topographical sheets covering the area of this exploration, 10 companion geological sheets, and 2 sheets upon which are shown two geological sections, each drawn from the 104th to the 120th meridian through the area covered by Mr. King's survey, has been engraved and printed, and will be ready for issue as soon as the volumes can be printed. The geological sections just mentioned are through a belt of country about 800 miles long, and are among the longest geological sections that have ever been made from actual field observations.

(See Appendix II.)

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GEOGRAPHICAL EXPLORATIONS AND SURVEYS OF THE ONE HUNDREDTH MERIDIAN.

Officer in charge, First Lieut. George M. Wheeler, Corps of Engineers, having under his orders First Lieuts. William L. Marshall and Eric Bergland, Corps of Engineers; First Lieuts. William L. Carpenter, Ninth Infantry; Rogers Birnie, jr., Thirteenth Infantry; C. C. Morrison, Sixth Cavalry; C. W. Whipple, Ordnance Corps; and Second Lieut. M. M. Macomb, Fourth Artillery; Acting Assistant Surgeons H. C. Yarrow and J. T. Rothrock, United States Army, who, in addition to their professional duties, were engaged in zoological and botanical labors.

The following scientists have also been attached to the expedition of the past year: Dr. F. Kampf, astronomical observer; Messrs. Jules Marcou, A. R. Conkling, and D. A. Joy, geologists; Dr. O. Loew, mineralogist, and Prof. F. W. Putnam, ethnologist.

At the commencement of the fiscal year the main sections of the survey were engaged in their field of operations, having left the rendezvous at Pueblo, Colo., and Los Angeles, Cal., in the prosecution of their labors of former years in areas as shown by portions of Atlas sheets Nos. 61c, 61 d, 65, 72, 73, 74, 77*a*, 77 B, 78*a* and 80*a*. (See progress map in Appendix JJ.)

The astronomical determinations of the year were confined to those needed to check the several lines of meander within the immediate field of survey.

The several parties were disbanded at Caliente, Cal., the then terminus of the Southern Pacific Railroad, and at West Las Animas, Colo., at the close of the field season in November and December, a number of the assistants repairing to Washington to prepare in the ensuing months the practical results, and at which point a small force of draughtsmen and computers was kept constantly employed in the reduction of field-notes and the production of finished maps.

A report of the special party intrusted to Lieutenant Bergland, Corps of Engineers, to determine as to the feasibility of the diversion of the Colorado River of the West, for purposes of irrigation, at or below the mouth of the Lower Grand Cañon, has been submitted. Examinations were made at such points as it was practicable for the party to reach in the seasons of labor available, and data bearing upon the physical features of the outlying mountainous sections, with their several passes, are contained in the report, which also includes a discussion of practicability of the diversion of this stream.

Of the six quarto volumes authorized to be published by the act of June 3, 1874, as amended by the act approved February 15, 1875, two volumes, namely, III (Geology) and V (Zoology) have been printed, as well as part 1 of volume IV, (Invertebrate Fossils.) The manuscript of volume II (Astronomy and Meteorology, including Barometric Altitudes) and the second part of volume IV is ready, while that for volumes VI (Botany) and VII (Ethnology, Philology, and Ruins) is in an advanced stage of preparation, as well as volume I, (Geographical Report.) The manuscript of The Declination of 2,018 Stars, by Prof. T. H. Safford, has also been completed. Seven published sheets have been added to the topographical atlas, and others are completed and in various stages of progress. Six geological-atlas sheets have been published, and three are now ready for, or in the hands of, the engraver.

The results determined by the several scientists connected with the investigation of the subjects of natural history are, in addition to the

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results primarily intended to exhibit the operations of the survey, namely, the preparation of a detailed map of the sections entered, with a description and delineation, so far as practicable, of their natural resources, and showing the distribution of the arable and arid portions, the former divisible into those sections which are susceptible of cultivation, those in which irrigation can be had, and into mining, timber, and grazing sections, the latter entirely valueless at the present or any near prospective date, for occupation or use in any remunerative capacity from such industry that is likely to venture within its borders.

The topographical maps, that have been prepared upon scales as follows: 1 inch to 8 miles, 1 inch to 4 miles, and 1 inch to 2 miles—forming the principal results of the survey, furnish information of immediate value to the different branches of the military service, and incidentally to the other departments of the Government and to the public.

The regular progress of this important work without interruption, it is believed, will commend itself to the attention of Congress, and it is earnestly recommended.

The amounts required to continue the survey, as estimated by Lieutenant Wheeler, are recommended, viz:

For continuing geographical surveys of the territory of the United States west of the 100th meridian	$95,000 00
For preparing and engraving plates and atlas sheets accompanying reports upon geographical surveys west of the 100th meridian	25,000 00

His annual report, with appendixes and estimates, is appended.

(See Appendix JJ.)

RECONNAISSANCES AND EXPLORATIONS.

There are at nearly all the headquarters of the four military divisions and the nine military departments officers of engineers, whose chief duty it is to collect geographical and other information, and these officers do, by means of their own explorations and surveys, and by collecting the notes, sketches, and maps made by the officers and soldiers belonging to the western posts, in their scouts and campaigns, add much, year by year, to the knowledge of the interior of the country, which is not only essential to the generals in command of these departments and divisions, but useful to the country generally.

By reason of the failure of the appropriation asked for by this Department to defray the expenses of the surveys designed to be made by these engineer officers in the current fiscal year, the persons employed have been discharged, and there are no means whatever available for the further prosecution of their surveys, which have produced in the last two years, and in most of the divisions and departments west of the Mississippi River, gratifying and useful results in the shape of reports and maps. Neither are there any funds available for the purchase and repair of instruments used in the field; for the purchase and repair of the office instruments, drawing-paper, &c., required in the preparation of maps from data now in this office and in the offices of the division and department engineers; for the pay of draughtsmen, or for the expenses attending the printing of maps for distribution to the Army and the country. On account of the unsettled condition of the Territories included in the western divisions and departments, it is especially desirable that the surveys by the engineer officers of these divisions and departments shall be continued, that the new data now available shall be added to the existing maps, and that the maps, which at the suspen-

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sion of the work were nearly ready, and those which can be prepared within the next fiscal year, shall be printed.

The appropriation necessary for the purpose, an estimate for which is included in the annual estimates, is urgently recommended.

The officers who have been thus serving the last fiscal year, are Maj. O. M. Poe, aid-de-camp (with the rank of colonel) to the General of the Army; Maj. G. L. Gillespie, at the headquarters of the Division of the Missouri; Capt. William Ludlow, at the headquarters Department of Dakota till May 9, and Lieut. Edward Maguire since that date; Capt. W. S. Stanton, at headquarters Department of the Platte; Lieut. E. H. Ruffner, at headquarters Department of Missouri; and Lieut. J. C. Mallery, at headquarters Division of the Pacific and Department of California.

During the last fiscal year there have been distributed by Maj. H. L. Abbot, from the engineer depot at Willet's Point, to officers engaged in surveys, an aggregate of 88 instruments.

(See Appendix KK.)

Col. O. M. Poe, A. D. C., major of engineers, &c., on duty at the headquarters of the Army, has supervised the compilation of a map of the Department of Texas, and a series of maps illustrating the campaigns of the army commanded by General Sherman in 1864–'65; and has also purchased and distributed to military divisions and departments such prismatic compasses, odometers, and drawing-instruments as were required to fill requisitions made upon him from time to time. His report is appended hereto.

(See Appendix LL.)

Maj. George L. Gillespie, on duty with the Lieutenant-General, commanding the Division of the Missouri, reports that the limited number of itineraries of scouts received at his office during the year has not permitted any great or specially important changes to be made in existing maps of the Western Territories. Sheets Nos. 2 and 3, of the map of Western Territories, have been completed; the former is ready to be printed, and the latter has been photolithographed in the office of the Chief of Engineers, and issued to the troops in the field. Sheet No. 4, of the same map, is still in course of preparation. A few important additions have been made to the Kansas, Texas, and Indian Territory map. Tracings of the following reservations and plans of posts were made: Camp Robinson, Nebraska; Camp Sheridan, Nebraska; Sidney Barracks, Nebraska; Fort Hartsuff, Nebraska; Cheyenne Agency, Dakota; San Antonio, Texas; Camp Douglas, Utah; Cantonment on the Sweetwater, Texas, and Fort Union, New Mexico. The book "Outline Description of the Posts in the Military Division of the Missouri," complete with map and plates, has been printed. A history of the several military posts and reservations of the Military Division of the Missouri, comprising the date of their declaration, their extent, and circumstances of their establishment, has been prepared for the office files of the division headquarters. Many tracings of sketches of scouts, possessing no topographical significance, have been made to complete the files of the Adjutant-General's Office. Disbursements for the engineer office at headquarters Department of Texas have been made by Major Gillespie.

Amount required for surveys for the fiscal year ending June 30, 1878, to be expended under the direction of the engineer officer at headquarters of the Division of the Missouri $6,000 00

(See Appendix MM.)

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In the Department of Dakota, Capt. William Ludlow was on the staff of the general commanding until the 9th of May, when he was relieved by Lieut. Edward Maguire. At the beginning of the fiscal year Captain Ludlow was engaged upon a reconnaissance of the Carroll road, a newly opened freight-route extending from Carroll, on the Upper Missouri, through the Judith Basin, to Camp Baker, and thence to Helena, Mont.; an examination of the routes from the north into the Yellowstone Park, and an astronomical determination of the positions of the military posts in Montana. A report of the reconnaissance, accompanied by reports of Messrs. George Bird Grinnell and Edward S. Dana, of Yale College, on the zoology and geology of the region explored, with descriptions of new fossils by R. P. Whitfield, and report of Lieut. R. E. Thompson, Sixth Infantry, has been received and will be found in Appendix NN.

On the 9th of May Lieutenant Maguire relieved Captain Ludlow and immediately proceeded as engineer officer of the command which was to take the field against the hostile Sioux. Lieutenant Maguire's report of the march preceding the battle of the Little Big Horn on the 25th and 26th of June, with a plan of the battle-field, is appended.

(See Appendix OO.)

Capt. W. S. Stanton, on duty with the general commanding the Department of the Platte, was engaged in such surveys in the field and office-work as could be done with the limited assistance which could be furnished him with the small amount of money available for the purpose. The field-work comprised a reconnaissance of a route for Indian supplies from Cheyenne, Wyo., to Red Cloud agency; a reconnaissance with the Big Horn and Yellowstone expedition of the last season under General Crook, and the inspection of the construction of a wrought-iron bridge over the North Platte River at Fort Laramie, full reports of which will be found in Captain Stanton's detailed report.

In the year ending the 30th of June, 1876, Captain Stanton had made 594 miles of reconnaissance with odometers, in addition to 61 miles of reconnaissance on horseback. During the year, 270 maps and 60 printed reports of explorations and reconnaissances with maps have been issued. The following is part of the work which should be executed in the Department of the Platte during the field season of 1877, and it is earnestly hoped that Congress will provide the necessary means therefor.

To complete the measurement and reconnaissance of all the routes in the department; to make a reconnaissance of a route from Grand Island, Nebraska, on the Union Pacific Railroad, via Fort Hartsuff and Camp Sheridan to the Black Hills, and also of the routes from the Black Hills to Camp Robinson and Fort Laramie; to reconnoiter a shorter route from the railroad to Fort Fetterman, and from the railroad to Camps Brown and Stambaugh; and to determine the position of many of the posts in the department for which a zenith telescope and astronomical transit are needed.

A part of this work was begun on returning from the expedition after the close of the fiscal year and 505 miles of the routes surveyed, in addition to the three reservations, when it was stopped by the necessity of discharging Captain Stanton's assistant for want of any appropriation whatever for his pay, or for the work.

During the year the procurement from the General Land Office, through the office of the Chief of Engineers, of the maps and manuscript notes of all the State and Territorial boundary surveys thus far made within the department, has been progressing, and they are now nearly all in Captain Stanton's possession. It now remains to procure

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copies of all the township plats which have been surveyed in Nebraska, Wyoming, and Utah, when, with them, the boundary surveys and the reconnaissances and determinations of posts proposed, an extensive revision and improvement in the maps of the department can be made. There being no money whatever applicable to it, this work is now entirely suspended and must continue so until further appropriations.

(See Appendix PP.)

During the past year Lieut. E. H. Ruffner has been on duty as engineer officer on the staff of the general commanding the Department of the Missouri. He has been employed in working up material on hand toward the completion of the map of the Department; an atlas of detail-sheets of the reconnaissance in the Ute country, 46 in number, and two other illustrative sketches have been completed and forwarded to the Engineer Bureau.

A report on communications between Northern New Mexico and Southern Colorado was made, accompanied by a general map and an atlas of 14 sheets of detail of a survey for a wagon-road from Fort Garland to Fort Wingate, New Mexico. It was printed in House Executive Document No. 172, Forty-fourth Congress, first session.

The usual number of maps have been issued, and a map of the Indian Territory, in 4 sections, has been completed, printed, and issued.

There has been but little field-work done in the Department of the Missouri during the last fiscal year for want of funds, the assistance of Lieutenant Ruffner having been limited to the services of one draughtsman, who has since been discharged, there being no appropriation from which he could continue to be paid. The valuable results which have heretofore been received from that department will therefore be interrupted till further appropriations by Congress for surveys by the engineer officers at the various headquarters of divisions and departments.

The most important survey during the year was at the sources of the Red River of Texas, which has just been completed. A report will be prepared of this, giving the usual natural history, geological, and meteorological descriptions.

In addition to his other duties, Lieutenant Ruffner has completed the military road from Santa Fé to Fernandez de Taos, N. Mex., under a special appropriation by Congress, and recommends the extension of the route to Fort Garland, Colo., where connection will be made with railroad communication.

Amount available for surveys at the end of year for next fiscal year.....	
Amount required for surveys in the Department of the Missouri, for the fiscal year 1877–'78, to be expended by the engineer officer of the department	$5,000 00
Amount on hand, military road Santa Fé to Ferandez de Taos, N. Mex...	595 35
Amount required to complete the road from Taos to Fort Garland.....	10,000 00

(See Appendix QQ.)

Lieut. J. C. Mallery, at the headquarters Military Division of the Pacific, reports that he made, during the year, a survey of the sources of water-supply for Camp Halleck, Nevada, and a report, map, and estimates were prepared for the action of the major-general commanding. I. W. Ward, assistant and draughtsman, in obedience to a division order, made a reconnaissance of the trail from Arcata, Cal., to Camp Gaston, Cal. The military reservations of Camps McDowell, Verde, and Apache, Arizona Territory, have been surveyed by Lieut. E. D. Thomas, 5th Cavalry, acting engineer officer Department of Arizona. Lieutenant Thomas has also been engaged in locating and constructing roads in Arizona. The roads from Black Cañon to Bowie's Ranch, Aqua Fria

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Valley, and from Prescott to Skull Valley, over the Sierra Prieta Mountains, were completed. The former road is 35½ miles in length, and shortens the distance from Prescott to Camp McDowell 18 miles. The latter road diminishes the distance from the southern part of the territory 19½ miles. Lieutenant Mallery states that the acting engineer officers of the Departments of Arizona and the Columbia made no reports to his office, and all that is known of what is done in those departments was gathered from such communications as were referred while being forwarded. Lieut. George Wilson, 12th Infantry, made a reconnaissance of the Trinity and Klamath Rivers from Camp Gaston, Cal., to the ocean. Sheets Nos. 1 and 3, map of the Department of Arizona, have been revised and redrawn. They have been photolithographed in Washington, by authority of the Chief of Engineers. Sheet No. 2 has been partly redrawn. Sheets Nos. 4, 5, and 6 have been projected and are well advanced. A map of the Department of California has been drawn and photographed in Lieutenant Mallery's office, and a map of the military division of the Pacific, on a scale of $\frac{1}{2500000}$, is in course of projection. The following is a summary of the office-work:

Number of maps projected and drawn	9
Number of maps traced	17
Number of photographic prints of maps	597
Number of field sketches of routes of march	20
Number of plans of buildings drawn	10

(See Appendix RR.)

ESTIMATES FOR AMOUNTS REQUIRED FOR MILITARY AND GEOGRAPHICAL SURVEYS, EXPLORATIONS, AND RECONNAISSANCES.

For military surveys and reconnaissances by the engineer officers attached to the various headquarters of military divisions and departments, and for the construction and publication of maps for use of the War Department and the Army, $50,000 will be required.

For geographical surveys of the territory of the United States west of the 100th meridian, there will be required for field and office work $95,000, and for preparing, engraving, and printing of plates and atlas-sheets $25,000.

OFFICE OF THE CHIEF OF ENGINEERS.

In the labors of the office I was assisted, on the 30th of June, by the following officers, in charge of the several divisions:

FIRST AND SECOND DIVISIONS.—*Fortifications, battalion, and engineer depot, lands, armaments, personnel, &c.*, Lieut. Col. Thomas L. Casey.

THIRD DIVISION.—*River and harbor improvements, &c.*, Maj. John G. Parke.

FOURTH AND FIFTH DIVISIONS.—*Property, accounts, estimates, funds, survey of the lakes, explorations, maps, instruments, &c.*, Maj. George H. Elliot.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen., Chief of Engineers,
Commanding Corps of Engineers.

Hon. J. D. CAMERON,
Secretary of War.

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LAWS

AFFECTING THE

CORPS OF ENGINEERS,

FORTY-FOURTH CONGRESS,

FIRST SESSION.

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LAWS

AFFECTING

THE CORPS OF ENGINEERS.

FORTY-FOURTH CONGRESS, FIRST SESSION, 1875-'76.

CHAP. 50.—An act to suspend the sale of the jail on Judiciary Square and for other purposes. April 10, 1876.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Chief Engineer of the Army be and he is hereby directed to suspend the sale of the jail on Judiciary Square in the city of Washington, and that the same be turned over to the use of the authorities of the District of Columbia, temporarily or until other jail facilities are provided, and that it shall be lawful for the courts of said District of Columbia to order the confinement of prisoners therein. Sale of jail on Judiciary Square suspended. Use of jail.

Approved, April 10, 1876.

CHAP. 53.—An act donating the military road running from Astoria, Oregon, to Salem, in that State, to the several counties through which it passes. April 11, 1876.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the military road from Astoria to Salem, in the State of Oregon, constructed under the following acts of Congress, to wit, acts approved February seventeenth, eighteen hundred and fifty-five; March second, eighteen hundred and fifty-seven; and June fourteenth, eighteen hundred and fifty-eight, be, and the same is hereby, donated to the several counties in said State through which it runs, to wit, Clatsop, Washington, Yam Hill, and Polk, to each such portion as runs through it; said counties hereafter to own and control the same; and such road is hereby abandoned as a military road. Military road from Astoria to Salem, Oregon, donated to counties. 1855, ch. 104, 10 Stat., 608. 1857, ch. 61, 11 Stat., 168. 1858, ch. 161, 11 Stat., 337.

Approved, April 11, 1876.

CHAP. 93.—An act to relinquish the interests of the United States in certain lands to the city and county of San Francisco, in the State of California. May 9, 1876.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That all the right and title of the United States to the following-described portion of the military reservation known as the Presidio, or Fort Point reservation, situated in the city and county of San Francisco, State of California, be, and the same are hereby, relinquished to the said city and county, and its successors, assigns, and vendees, for the benefit of persons who, if the said land had not been reserved for public use, would have been entitled thereto under the ordinances numbered eight hundred, of the city of San Francisco, ratified by act of the legislature of said State, approved on the twenty-seventh day of March, eighteen hundred and sixty-eight, entitled "An act to confirm a certain order passed by the board of supervisors of the city of San Francisco," relating to these premises, and being more particularly described as follows: Commencing at the southeasterly corner of the said Presidio, or Fort Point reservation, and thence running in a direct line due north to the shore-line of the Bay of San Francisco; thence westerly along the said shore-line to a point eighty Part of Presidio reservation relinquished to San Francisco. Description.

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feet west of the easterly line of the said Presidio, or Fort Point reservation, as established by the United States authorities, said eighty feet being relinquished for a public highway, or street, named Lyon street; thence southerly to a point on the southerly line of said reservation, where the west line of Lyon street intersects said line; thence easterly to the point of commencement, to conform as near as possible to the plan of the city-map of streets of San Francisco outside of reservation, said plan being now on file in the office of the War Department of the city of Washington: *Provided*, That Lyon street shall be extended to the Bay of San Francisco eighty feet wide, and is hereby dedicated for a public highway and street forever: *Provided further*, That Broadway, Vallejo, Green, Union, Filbert, Greenwich, Lombard, Chestnut, Francisco, Bay, North Point, Jefferson, Tonquin, and Lewis streets as laid down on the official map of the city and county of San Francisco, be extended westerly to intersect the easterly line of Lyon street as herein provided, be, and are hereby, dedicated as public highways and streets forever.

Streets.

Proviso.

Proviso.

Approved, May 9, 1876.

June 20, 1876.

CHAP. 135.—An act making appropriations for fortifications and for other works of defense, and for the armament thereof, for the fiscal year ending June thirtieth, eighteen hundred and seventy-seven, and for other purposes.

Appropriation.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the sum of one hundred thousand dollars be, and the same is hereby, appropriated, out of any money in the Treasury not otherwise appropriated, for the protection, preservation, and repair of fortifications and other works of defense, for the fiscal year ending June thirtieth, eighteen hundred and seventy-seven; the same to be expended under the direction of the Secretary of War; also the following for armament of fortifications, namely:

Repair of fortifications.

Armament of fortifications.

For the armament of sea-coast fortifications, including heavy guns, Gatling guns, and howitzers for flank defense, carriages, projectiles, fuzes, powder and implements, their trial and proof, and all necessary expenses incident thereto, one hundred and sixty-five thousand dollars.

Torpedoes.

Proviso.

For torpedoes for harbor defenses, and preservation of the same, and for torpedo experiments in their application to harbor and land defense, and for instruction of engineer battalion in their preparation and application, fifty thousand dollars: *Provided*, That the money herein appropriated for torpedoes shall only be used in the establishment and maintenance of torpedoes to be operated from shore-stations for the destruction of an enemy's vessel approaching the shore or entering the channel and fairways of harbors.

* * * * * * *

Approved, June 20, 1876.

June 30, 1876.

CHAP. 157.—An act to provide temporarily for the expenditures of the Government.

Use of unexpended balances of year 1876, during ten days from June 30, 1876.

Post, pp. 78, 95, 122, 131, 168.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That for a period not exceeding ten days from and after the thirtieth day of June, eighteen hundred and seventy-six, unless the regular appropriations shall have been previously made for the service of the fiscal year ending the thirtieth day of June, eighteen hundred and seventy-seven, it shall be lawful to use for the necessary service of the Government, any unexpended balance which may exist of the appropriations made for the service of the fiscal year ending June thirtieth, eighteen hundred and seventy-six; and in case no sufficient balance remains at the conclusion of the fiscal year ending June thirtieth, eighteen hundred and seventy six to the credit of any appropriation, the necessary amount is hereby appropriated out of any money in the Treasury not otherwise appropriated, and no greater amount shall be expended under this act than such proportional sum of the appropriations of the fiscal year ending June thirtieth, eighteen hundred and seventy-six, as ten days time bears to the whole of said fiscal year and such expenditure shall be only for the necessary operations of th Government under existing laws. All sums expended under this act shall be charged to, and be deducted from, the appropriations for like service for the fiscal year ending June thirtieth, eighteen hundred and seventy-seven.

Appropriation.

Limit of expenditure.

Expenditure charged to appropriation for year ending June 30, 1877.

Approved, June 30, 1876.

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CHAP. 169.—An act to authorize the construction of a ponton-bridge across the Mississippi River from some feasible point in La Crosse County, in the State of Wisconsin, to some feasible point in Houston County, in the State of Minnesota. July 6, 1876.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the city of La Crosse to construct a pile and ponton bridge across the Mississippi River at some feasible point in La Crosse County in the State of Wisconsin, so as to connect with the opposite shore of the said river, in the State of Minnesota; said bridge to be built subject, except as herein modified, to all the terms, requirements, and limitations contained in the act entitled "An act to legalize and establish a ponton-railway-bridge across the Mississippi River at Prairie du Chien, and to authorize the construction of a similar bridge at or near Clinton, Iowa," approved June sixth, eighteen hundred and seventy-four, so far as they may be applicable thereto.

Pile and ponton bridge may be built by city of La Crosse.

How to be built.

1874, ch. 224, 18 Stat., 62.

SEC. 2. That the bridge shall be constructed with one suitable ponton-draw of not less than four hundred feet in width, located over the main channel of the river: *Provided*, That said bridge shall not be built or commenced until the plan and specifications for its construction have been submitted to the Secretary of War for his approval, nor until he shall approve the plan and the location of said bridge; and if any change be made in the plan of construction of said bridge at any time, such change shall be subject to the approval of the Secretary of War; and any change in the construction or any alteration of said bridge that may be directed at any time by Congress or the Secretary of War shall be made at the cost and expense of the owners thereof: *And provided further*, That the right is hereby reserved to Congress to alter amend or repeal this act; and in case of the repeal of this act, the bridge shall be removed without expense to the United States, and if this act be amended any change or alteration required of the bridge shall be without cost to the United States.

Width of ponton-draw.

Approval of plan by Secretary of War.

Changes in construction.

Right to alter, amend, or repeal.

Alterations without cost to United States.

Approved, July 6, 1876.

CHAP. 172.—An act authorizing the Nebraska City Bridge Company to construct a ponton railway-bridge across the Missouri River at Nebraska City in Otoe County, Nebraska. July 8, 1876.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Nebraska City Bridge Company, a corporation having authority from the State of Nebraska and from the State of Iowa, its successors and assigns, to build, maintain, and operate a ponton railway-transit and wagon-bridge across the Missouri River at Nebraska City, in the county of Otoe, and State of Nebraska; and said company, its successors or assigns, shall keep up and maintain a suitable ponton-draw of not less than three hundred feet in length; and that said draw shall be opened promptly, upon reasonable signal, for the passage of boats or rafts; but in no case shall unreasonable delay occur in the opening of said draw before or after the passage of trains; and the company, corporation, or individuals having the charge or control of said bridge shall, for the security of navigation, maintain, from sunset to sunrise, throughout the year, such lights on said bridge as may be required by the Light-House Board.

Ponton railway-transit and wagon bridge at Nebraska City.

Width of draw.

Opening of draw.

Lights on bridge.

SEC. 2. That all railway-companies desiring to use said ponton-bridge shall have, and be entitled to, equal rights and privileges in the use of the same, and in the use of the machinery and fixtures thereof, and of all approaches thereto, under and upon such terms and conditions as shall be prescribed by the Secretary of War, upon hearing the allegations and proofs of the parties in case they shall not agree; and the United States shall have the right of way for postal and telegraphic purposes across said bridge; and no greater charge shall be made for the transmission over the same of the mails, the troops, and munitions of war of the United States than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge; and in case of any litigation arising from any obstruction, or alleged obstruction, to the navigation of the said Missouri River, created by the construction of said bridge under this act, the cause or question arising may be tried before the district or circuit court of the United States of any State wherein the obstruction exists.

Use of bridge by railway companies.

Right of way for postal and telegraphic purposes.

Charge for mails and troops.

Suits for obstruction of river.

Where triable.

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Amendment of act without liability for damages.

SEC. 3. That the right to alter or amend this act so as to prevent or remove all material obstructions to the navigation of said Missouri River is hereby expressly reserved, without any liability to the Government for damages on account of the alteration or amendment of this act, or on account of the prevention or requiring the removal of any such obstructions; and if any change be made in the plan of construction of said ponton-bridge, such change shall be subject to the approval of the Secretary of War; and any change in the construction or any alteration of said bridge that may be directed at any time by Congress or the Secretary of War shall be at the cost and expense of the owners thereof. Said bridge shall be constructed, as near as may be practicable, upon the line heretofore surveyed and established by the Nebraska City Bridge Company.

Alterations subject to approval.

Alterations, when to be made.

Location.

Regulations for security of navigation.

SEC. 4. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object, the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War, the bridge shall not be built.

Plans of construction, etc., to be submitted.

Bridge not to be built till plan submitted.

Approved, July 8, 1876.

July 10, 1876.

CHAP. 177.—An act to continue the provisions of an act entitled "An act to provide temporarily for the expenditures of the Government," &c., &c.

Extension of appropriation for ten days.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the provisions of an act entitled "An act to provide temporarily for the expenditures of the Government" approved June thirtieth, eighteen hundred and seventy-six be, and the same are hereby, extended and continued in full force and effect for the period of ten days from and after the tenth day of July, eighteen hundred and seventy-six, and no longer.

Ante, p. 65.
Post, pp. 95, 122, 131, 168.

Approved July 10, 1876.

July 19, 1876.

CHAP. 213.—An act authorizing the repavement of Pennsylvania avenue.

Commissioners for paving Pennsylvania avenue.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the President of the United States be, and he is hereby, directed to detail General H. G. Wright and General Q. A. Gilmore, of the Engineer Corps of the Army, who, with Edward Clark, of Washington, District of Columbia, shall form a commission, whose duty shall be to select and determine the best kind of pavement to be used in paving Pennsylvania avenue and all intersections of streets, and avenues, and alleys crossing the same, including the triangular spaces directly connecting with the Pennsylvania-avenue pavement, abutting on parts of squares numbered two hundred and fifty-four, two hundred and fifty-six, three hundred and twenty-three, three hundred and forty-eight, and four hundred and eight, but not including the side-walks; and to have said thoroughfare paved therewith from the northwest gate of the Capitol-grounds, to and including the crossing of Fifteenth street west, with such a pavement as they, or a majority of the said commission, may agree upon.

Organization.

SEC. 2. That within ten days after the passage of this act, or as soon thereafter as may be, the commission named herein shall meet and organize by the election of a president and secretary from among their number, and shall proceed to perform the duties herein imposed upon them; and as soon as practicable, they shall give notice for one week, in a daily paper published in each of the cities of Washington, Philadelphia and New York, for proposals, with full specifications, for paving said avenue: *Provided*, That said pavement shall be of the best material laid in the most substantial manner, and without unnecessary delay; and that a good and sufficient bond to the United States, with sureties, to be ap-

Notice for proposals.

Pavement.

Contractor's bond.

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proved by the commission, shall be exacted, guaranteeing that the terms of any contract or contracts shall be strictly and faithfully observed, and that the contractor shall keep the said pavement in good repair for the term of three years; and said commission shall retain ten per centum of the cost of the work as an additional security and a guarantee fund to keep the same in repair for the said term, which said per centum shall be invested in the Bonds of the United States and the interest thereon paid to said contractors.

Repairs.

Ten per centum retained.

SEC. 3. That the cost of laying down said pavement shall be paid for in the following proportions and manner: The Washington and Georgetown Railroad Company shall bear all of the expense for that portion of the work lying between the exterior rails of the tracks of the road, and for a distance of two feet from and exterior to the track on each side thereof, and of keeping the same in repair; but the said railroad company, having conformed to the grade established by the Commissioners, may use cobble-stone or Belgian rock in paving their tracks, or the space between their tracks, as the commissioners shall direct. The United States shall pay the cost of paving the spaces between its property and the part of the avenue to be paid for by said railroad company, and one-half of the cost of paving the intersection of the streets and avenues, less that to be paid by the railroad company, and the other half shall be paid out of the revenues of the District of Columbia, and the residue of the cost of such paving shall be paid as follows: One-third by the owners of private property lying and abutting on said Pennsylvania avenue, in proportion to their frontage thereon, as hereinafter provided; one-third by the United States; and one-third out of the general revenue of the District of Columbia; and the amount required to pay the part of said cost assumed by the United States shall be paid out of any money in the Treasury not otherwise appropriated; and the amount required to pay the part of said cost charged to the District of Columbia shall also be paid out of any money in the United States Treasury not otherwise appropriated, but the money so paid shall be reimbursed to the Treasury of the United States by the District of Columbia from money derived from taxation upon the warrants or orders of said commission duly audited in the Treasury Department: *Provided*, That the property owners of such parts of squares two hundred and fifty-four, two hundred and fifty-six, three hundred and twenty-three, three hundred and forty-eight, and four hundred and eight, as are abutting upon said pavement, shall be assessed at the same rate per front foot as the owners on Pennsylvania avenue; *And provided further*, That the space between Seventh and Eighth streets, opposite the locality now occupied by the Washington Market Company, shall be paid by the District of Columbia, unless the suit now pending as to the ownership of said ground shall be decided against the said District when the same shall be refunded, with legal interest, by the Washington Market Company to said District.

Pavement, how paid for.

Railroad track.

Appropriation.

Reimbursement.

Property owners in certain squares.

Washington Market Company.

SEC. 4. That assessments shall be made by the Commissioners of the District of Columbia upon the owners of said private property on said avenue and spaces, and upon said railroad company respectively, provided for in section three of this act, and the sums so found collected by the collector of the District of Columbia, and paid into the Treasury of the United States, where it shall be held as a special fund for the specific purpose herein named; and such fund, together with such sum as shall be found to be due and payable from the United States for its proportion of the cost of said pavement, together with the proportion due from the District of Columbia, shall be paid by the Secretary of the Treasury, on the warrant or order of the commission, or a majority thereof, herein authorized, in such amounts and at such times as they may deem safe and proper in view of the progress of the work.

Assessments, by whom made.

Deposit in Treasury.

Payments from Treasury.

SEC. 5. That the cost of laying down said pavement exclusive of the work charged to and paid for by the Washington and Georgetown Railroad Company, but including the removal of the present pavement, grading the avenue, and all other work and materials necessary to fully complete said pavement for use, shall not exceed the sum of four dollars and thirty cents per square yard: *Provided* said pavement shall be fully completed and ready for use December first, eighteen hundred and seventy-six.

Limit of cost.

Time of completion.

SEC. 6. That if the Washington and Georgetown Railroad Company, or any private citizen or other corporation or person, shall neglect or refuse to pay the amount assessed for the paving herein authorized, (within

Default in paying assessments.

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thirty days after the notification of such assessment shall have been published in one or more papers printed in the District of Columbia,) in front of, or adjoining their property, when the work so fronting or adjoining their property shall have been completed to the satisfaction of the commission provided for in this act, and assessed by the District of Columbia Commissioners, the said Commissioners of the District of Columbia shall issue certificates of indebtedness against the property, which certificates shall bear interest at the rate of ten per centum per annum until paid, and which, until they are paid, shall remain and be a lien upon the property on or against which they are issued. And if the said certificates are not paid within one year, the said Commissioners of the District of Columbia shall, upon the application of the holder thereof, proceed to sell the property against which they are issued, or so much thereof as may be necessary to pay said tax; such sales to be first duly advertised, daily, for one week, in some newspaper published in the city of Washington, and to be made at public auction to the highest bidder; and a deed given by the said Commissioners of the District of Columbia in pursuance hereof shall be deemed and held to be a good and perfect title to any property bought at such sale hereby authorized: *Provided*, That the owner of said real estate shall have the right to redeem the property sold by paying the amount of purchase-money and ten per centum, with costs, on the amount of the said purchase, within one year from the date of the sale.

Certificates of indebtedness.

Lien of certificate.

Sale of property on non-payment of certificate.

Redemption.

Certain portion not to be repaved, unless, etc.

SEC. 7. That the said paving-commission shall not repave that portion of Pennsylvania avenue between Ninth and Tenth streets on the north side of the railroad track, unless it may be necessary for them so to do to perfect the whole system. Where street-railroads cross Pennsylvania avenue, the pavement between their tracks shall conform to the kind of pavement used on the said avenue; and the companies owning these intersecting railroads shall pay for paving the same in the same manner and proportion as is required, by section three, of the Georgetown and Washington Railroad Company.

Intersecting railroads.

Water and gas mains, etc.

SEC. 8. That it shall be the duty of the Commissioners of the District of Columbia to see that all water and gas mains service-pipes, and sewer-connections are laid without delay to the contractors before the pavement authorized by this act is put down; and it shall be the duty of the board of water-commissioners and of the Washington Gas-Light Company, under the direction of the said paving-commissioners, to take up, lay, and replace all gas-pipes, water-mains, and connections on said Pennsylvania avenue, at such time and places as said paving-commission may direct; and the old wood paving-blocks, which are required to be removed under this act, shall be delivered to the said Commissioners of the District of Columbia for such use or disposition as they may see fit to make.

Wooden paving-blocks.

Appropriation.

SEC. 9. That the sum of three thousand dollars is hereby appropriated out of any money in the Treasury of the United States not heretofore appropriated, and a like amount is directed to be paid by the District of Columbia Commissioners to the said paving-commission, to defray the necessary expenses of said commission.

Expenses of Commission.

Approved, July 19, 1876.

July 21, 1876.

CHAP. 221.—An act to continue the provisions of an act entitled "An act to provide temporarily for the expenditures of the Government."

Appropriations for expenditures of Government continued.

Ante, pp. 65, 78. *Post*, 122, 131, 168.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the provisions of an act entitled "An act to continue the provisions of an act entitled an act to provide temporarily for the expenditures of the Government," approved June thirtieth, eighteen hundred and seventy-six, approved July tenth, eighteen hundred and seventy-six, be, and the same are hereby, extended and continued in full force and effect, until and including the thirty-first day of July, eighteen hundred and seventy-six.

Approved, July 21, 1876.

July 22, 1876.

CHAP. 224.—An act to authorize the Secretary of War to purchase a parcel of land on the island of Key West, Florida.

Purchase of land on island of Key West.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized to purchase, for the use of the United States, at a price which shall be agreed upon between him and the

owners, and not to exceed two thousand dollars, a certain parcel or tract not exceeding five acres of land claimed by W. C. Maloney and wife, lying and situate on the island of Key West, Florida, and adjoining the military reservation on said island: *Provided*, That the title of said parties to said property shall be found to be in all respects good and valid in law and equity; but this authority shall expire at the end of one year from the passage of this act, and the necessary amount of money to pay for the said land in the event of purchase is hereby appropriated out of any money in the Treasury not otherwise appropriated. Appropriation.

SEC. 2. That if the Secretary of War and the owners of said property shall be unable to agree upon a price to be paid by the United States for said land, or if for any reason the United States shall fail to acquire the title to the same within a reasonable time after the passage of this act, then it shall be the duty of the Secretary of War to cause the possession of said property, if the same belongs to the said Maloney and wife, or such part of it as is now or may be occupied by the United States, to be restored to them. Possession restored in case of disagreement.

Approved, July 22, 1876.

CHAP. 226.—An act making appropriations for the support of the Army for the fiscal year ending June thirtieth, eighteen hundred and seventy-seven, and for other purposes. July 24, 1876.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, for the support of the Army, for the year ending June thirtieth, eighteen hundred and seventy-seven, as follows: Appropriations for support of Army for year ending June 30, 1877.

* * * * * * *

ENGINEER DEPARTMENT.

For engineer depot at Willet's Point, New York, namely: Engineer depot at Willet's Point.

For remodeling portions of bridge-equipage to make it correspond with the new patterns; for necessary materials for properly drilling the engineer-companies in field-duties; for incidental expenses of the depot, fuel, forage, chemicals, stationery, extra-duty pay, purchase of animals, and ordinary repairs, five thousand dollars.

* * * * * * *

SEC. 2. That when any officer travels under orders, and is not furnished transportation by the Quartermaster's Department, or on a conveyance belonging to or chartered by the United States, or on any railroad on which the troops and supplies of the United States are entitled to be transported free of charge, he shall be allowed eight cents a mile, and no more, for each mile actually traveled under such order, distances to be calculated by the shortest usually traveled route; and so much of section twelve hundred and seventy-three of the Revised Statutes, or of any act as conflicts with the provisions of this section, is hereby repealed; and no part of the sum appropriated by this act shall be used for the payment of any officer of the field or line who, by appointment or otherwise, shall be in the performance of any duties of a civil nature in or about any of the Executive Departments of the Government other than for his pay and allowances as an officer of the Army. Army officers to have mileage. R. S., 1273, p. 220, amended. Army officers not to have additional pay for civil duties.

* * * * * * *

SEC. 4. That the whole subject matter of reform and reorganization of the Army of the United States shall be referred to the commission hereinafter provided for, who shall carefully and thoroughly examine into the matter with reference to the demands of the public service, as to the number and pay of men and officers and the proportion of the several arms and also as to the rank pay and duties of the several staff corps, and whether any and what reductions can be made either in the line or staff, in numbers or in pay, by consolidation or otherwise consistently with the public service, having in view a just and reasonable economy in the expenditure of public money, the actual necessities of the military service, and the capacity for rapid and effective increase in time of actual war. The commission hereby created shall consist of two members of the Senate and two members of the House of Representatives to be appointed by the presiding officers of each House respectively of the Secretary of War, and two officers of the Army one from the line and one from the Staff Corps, to be selected by the President Reform and organization of Army. *Post*, p. 216. Commission constituted.

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Duties.

with special reference to their knowledge of the organization, and experience in service. Such Commission shall assemble as soon as practicable and proceed to the consideration of the matters with which they are charged, and make report to Congress by the first day of the next session through the President of the United States, with all the evidence record or otherwise which they shall have received and considered. And the sum of one thousand dollars is hereby appropriated from the contingent fund of the War Department to defray the expenses of such commission to be expended under the direction of the president of said Commission.

Expenses.

Approved, July 24, 1876.

July 29, 1876.

CHAP. 239.—An act to amend an act approved May eight, eighteen hundred and seventy-four, in regard to leave of absence of Army officers.

1874, ch. 154, 18 Stat., 43, Amended.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That an act approved May eighth, eighteen hundred and seventy-four, in regard to leave of absence of Army officers, be, and the same is hereby, so amended that all officers on duty shall be allowed, in the discretion of the Secretary of War, sixty days' leave of absence without deduction of pay or allowance: *Provided*, That the same be taken once in two years: *And provided further*, That the leave of absence may be extended to three months, if taken once only in three years, or four months if taken only once in four years.

Leaves of absence to Army officers.

Proviso.

This act shall take effect from and after its passage.

Approved, July 29, 1876.

July 31, 1876.

CHAP. 246.—An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and seventy-seven, and for other purposes.

Appropriations for sundry civil expenses.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, for the objects hereinafter expressed, for the fiscal year ending June thirtieth, eighteen hundred and seventy-seven, namely:

* * * * * * *

SURVEYS OF NORTHERN AND NORTHWESTERN LAKES AND MISSISSIPPI RIVER.

Surveys of northern and northwestern lakes, etc.

For continuing surveys of Lakes Erie and Ontario; determination of points in aid of State surveys and construction of maps; continuation of triangulation south from Chicago and east to Lake Erie; survey of the Mississippi River, and miscellaneous, one hundred thousand dollars.

BUILDINGS AND GROUNDS IN AND AROUND WASHINGTON.

Public grounds in Washington, D. C.

Improvement and care of public grounds: For filling in and improving grounds south of Executive Mansion, five thousand dollars.

For ordinary care and extension of green houses at the nursery, one thousand five hundred dollars.

For ordinary care of Lafayette Square, one thousand dollars.

For annual repair of fences, one thousand dollars.

For manure and hauling the same, two thousand dollars.

For painting iron fences, two thousand dollars.

For repair of seats, five hundred dollars.

For purchase and repair of tools, five hundred dollars.

For trees, tree-stakes lime and whitewashing, three thousand dollars.

For removing snow and ice, one thousand dollars.

For flowers, pots, twine, Italian lycopodium, and so forth, five hundred dollars.

For abating nuisances, five hundred dollars.

For care of and repairs to fountains in the public grounds, five hundred dollars.

Pedestal for statue of General G. H. Thomas.

For pedestal for the statue of General George H. Thomas, twenty-five thousand dollars: *Provided*, That the Secretary of War and the chairman of the Committee on public buildings and grounds of the Senate and the chairman of public buildings and grounds of the House of Representatives are hereby appointed a committee to select and designate such place upon the public grounds in Washington City which in their

Committee to select site.

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judgment will be most appropriate, where said monument shall be erected.

* * * * * * *

For repairs of the Executive Mansion, refurnishing the same, and fuel for the same, and for care and necessary repairs of the green houses, seventeen thousand dollars. Executive Mansion.

* * * * * * *

For lighting the Executive Mansion, namely, for gas, pay of lamp-lighters, gas-fitters plumbers and plumbing, lamps lamp-posts, matches and repairs of all kinds, fuel for watchmen's lodges and for green houses at the nursery, nineteen thousand dollars: *Provided*, That the superintendent of meters at the Capitol shall hereafter take the statement of the meters of the several Department buildings in the city of Washington, and render to the proper accounting officers of the Treasury Department the consumption of gas each month in said buildings respectively. Lighting Executive Mansion. State of meters in Department buildings to be taken, etc.

For repairing and extending water-pipes, purchase of apparatus to clean them, and for cleaning the springs that supply the Capitol, Executive Mansion, and War and Navy Departments, five thousand dollars. Water-pipes, etc.

For ordinary repairs to Benning's and the Anacostia and Chain bridges, one thousand dollars. Benning's, Anacostia, and Chain bridges.

Washington aqueduct: For engineering, maintenance, and general repairs, eighteen thousand dollars. Washington aqueduct.

For repairs of Georgetown reservoir, four thousand dollars.

For improvement and care of all the various public reservations, six thousand dollars.

For continuing the improvement of Reservation number three, five thousand dollars.

For repairs and care of the telegraph to connect the Capitol with the Departments, and the Public Printing office, five hundred dollars. Department telegraph.

* * * * * * *

For geographical surveys of the Territories west of the one hundredth meridian, twenty thousand dollars. Geographical surveys.

For preparing, engraving, and printing the cuts, charts, plates, and atlas sheets for geographical surveys west of the one hundredth meridian, ten thousand dollars. Charts, plates, etc.

* * * * * * *

Approved, July 31, 1876.

CHAP. 243.—An act to continue the provisions of an act entitled "An act to continue the provisions of an act entitled 'An act to provide temporarily for the expenditures of the Government.'" Aug. 1, 1876.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the provisions of an act entitled "An act to continue the provisions of an act entitled 'An act to provide temporarily for the expenditures of the Government'" approved July twenty-first, eighteen hundred and seventy-six, be, and the same are hereby, extended and continued in full force and effect until and including the tenth day of August, eighteen hundred and seventy-six. Appropriations for expenditures of Government continued. *Ante*, pp. 65, 78, 95. *Post*, pp. 131, 168.

Approved, August 1, 1876.

CHAP. 250.—An act providing for the completion of the Washington Monument. Aug. 2, 1876.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there be, and is hereby appropriated, out of any money in the Treasury not otherwise appropriated, the sum of two hundred thousand dollars payable in four equal annual instalments to continue the construction of the Washington Monument in the city of Washington: *Provided*, That before any portion of said sum shall be expended, the proper officers of the Washington National Monument Society, incorporated by the act approved February twenty-sixth, eighteen hundred and fifty-nine, entitled "An act to incorporate the Washington National Monument Society," shall transfer and convey to the United States in due form all the property, easements, rights, and privileges, whether in possession, or in action, or in expectancy, belonging to the said corporation, to the uses and for the purposes set forth in said act of incorporation; and the said charter is so amended as to authorize the executive officers of said corporation to make said transfer and conveyance in consideration of the sum herein appropriated: *Provided*, That nothing herein shall be so construed as to Appropriation. Washington Monument. Property to be transferred to U. S. 1859, ch. 60, 11 Stat., 386. Society may continue organization.

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prohibit said society from continuing its organization for the purpose of soliciting and collecting money and material from the States, associations, and the people, in aid of the completion of the Monument and acting in an advisory and co-operative capacity with the Commission hereinafter named until the completion and dedication of the same.

Commission to supervise construction.

And the construction of said monument shall be under the direction and supervision of the President of the United States, the Supervising Architect of the Treasury Department, the Architect of the Capitol, the Chief of Engineers of the United States Army, and the First Vice President of the Washington National Monument Society, which officers are hereby constituted a joint commission for that purpose, and in accordance with the laws regulating contracts and the construction of public buildings by the Treasury Department; and detailed reports of such expenditures shall be annually submitted to Congress.

[Reports.

Examination of foundation.

SEC. 2. That prior to commencing any work on said monument an examination shall be made as to the foundation of the monument in order to thoroughly ascertain whether it is sufficient to sustain the weight of the completed structure, and if the same shall be found insufficient then the further continuance of the work shall not be authorized by anything herein contained until the further action of Congress.

Approved, August 2, 1876.

Aug. 12, 1876.

CHAP. 264.—An act to continue the provisions of an act entitled "An act to provide temporarily for the expenditures of the Government."

Appropriations for support of Government continued.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the provisions of an act entitled "An act to continue the provisions of an act entitled 'An act to provide temporarily for the expenditures of the Government,' approved June thirtieth, eighteen hundred and seventy-six," approved July thirty-first, eighteen hundred and seventy-six, be, and the same are hereby, extended and continued in full force and effect, until and including the fourteenth day of August, eighteen hundred and seventy-six.

Ante, pp. 65, 78, 95, 122.
Post, p. 168.

Approved, August 12, 1876.

Aug. 14, 1876.

CHAP. 267.—An act making appropriations for the construction, repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes.

Appropriations for rivers and harbors.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums of money be, and are hereby, appropriated, to be paid out of any money in the Treasury not otherwise appropriated, to be expended, under the direction of the Secretary of War, for the repair, preservation, construction, and completion of the following public works hereinafter named.

Dunkirk. For the improvement of the harbor at Dunkirk, New York, eighteen thousand dollars.

Buffalo. For the improvement of the harbor at Buffalo, New York, eighty-five thousand dollars.

Wilson. For the improvement of the harbor at Wilson, New York, ten thousand dollars.

Oak Orchard. For the improvement of the harbor at Oak Orchard, New York two thousand dollars.

Pultneyville. For the improvement of the harbor at Pultneyville, New York three thousand dollars.

Great Sodus Bay. For the improvement of the harbor at Great Sodus Bay, New York, five thousand dollars.

Hell Gate. For removing obstructions in the East River and Hell Gate, New York, two hundred and fifty thousand dollars.

Superior Bay. For the improvement of the natural entrance to Superior Bay, Wisconsin, three thousand dollars.

Du Luth. For the improvement of the harbor at Du Luth, Minnesota, fifteen thousand dollars. Said appropriation is made upon the express condition that it shall be without prejudice to either party in the suit now pending between the State of Wisconsin, plaintiff, and the city of Du Luth and the Northern Pacific Railroad, defendants.

Ontonagon. For the improvement of the harbor at Ontonagon, Michigan, fifteen thousand dollars.

Eagle Harbor. For the improvement of Eagle Harbor, Michigan, twelve thousand dollars.

Marquette. For the improvement of the harbor at Marquette, Michigan, two thousand dollars.

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For the improvement of the harbor at Frankfort, Michigan, three thousand dollars. Frankfort.

For the improvement of the harbor at Manistee, Michigan, fourteen thousand dollars. Manistee.

For the improvement of the harbor at Ludington, Michigan ten thousand dollars. Ludington.

For the improvement of the harbor at Pentwater, Michigan, ten thousand dollars. Pentwater.

For the improvement of the harbor at White River, Michigan, five thousand dollars. White River.

For the improvement of the harbor at Muskegan, Michigan, fifteen thousand dollars. Muskegan.

For the improvement of the harbor at Grand Haven, Michigan, fifteen thousand dollars. Grand Haven.

For the improvement of the harbor at Green Bay, Wisconsin, eight thousand dollars. Green Bay.

For the improvement of the harbor at Menomonee, Wisconsin, eight thousand dollars. Menomonee.

For the improvement of the harbor at Ahnepee, Wisconsin, eight thousand dollars. Ahnepee.

For the improvement of the harbor at Two Rivers, Wisconsin, five thousand dollars. Two Rivers.

For the improvement of the falls of Saint Anthony, Minnesota, one hundred and twenty thousand dollars. Falls of Saint Anthony.

For the improvement of Minnesota River, Minnesota, ten thousand dollars. Minnesota River.

For the improvement of the harbor at Toledo, Ohio, sixty thousand dollars. Toledo.

For the improvement of the harbor at Sandusky City Ohio, twenty-five thousand dollars. Sandusky City

For the improvement of the harbor at Vermillion, Ohio, five thousand dollars. Vermillion.

For a breakwater at Cleveland Harbor, Ohio, fifty thousand dollars. Cleveland.

For repair of east pier at Cleveland, Ohio, eight thousand dollars; and the Secretary of War is hereby authorized to agree with the Pittsburgh and Cleveland Railroad Company for such use and occupancy of said pier as is consistent with the public interests, upon such terms and conditions as he deems reasonable and just; and in case said railroad company shall neglect or refuse to make an agreement satisfactory to the Secretary of War, upon a certificate of that fact to the Attorney-General it shall be the duty of the latter officer to enforce the rights of the United States in the premises by appropriate action. Agreement to be made with Pittsburgh and Cleveland Railroad Company.

For the improvement of Connecticut River below Hartford Connecticut, twenty thousand dollars. Connecticut River.

For the improvement of the harbor at Fall River, Massachusetts, ten thousand dollars. Fall River.

For the improvement of the harbor at New Bedford, Massachusetts, ten thousand dollars. New Bedford.

For the improvement of Penobscot River, Maine, ten thousand dollars; four thousand dollars of which shall be expended at or near the "Narrows" in said river at Bucksport. Penobscot River.

For the improvement of Cocheco River, New Hampshire, fourteen thousand dollars. Cocheco River.

For the improvement of the harbor at Burlington, Vermont, twenty thousand dollars. Burlington.

For the improvement of the harbor at Swanton, Vermont, two thousand dollars. Swanton.

For the construction of Ice Harbor at Chester Pennsylvania, two thousand six hundred dollars. Chester.

For the improvement of Passaic River, New Jersey, ten thousand dollars. Passaic River.

For removing obstructions from, and the improvement of, the harbor at Wilmington, Delaware, sixteen thousand dollars. Wilmington.

For the construction of piers in Delaware Bay near Lewes, Delaware, thirty thousand dollars. Lewes.

For the improvement of the harbor at Chicago, Illinois, five thousand dollars. Chicago.

For the improvement of the Des Moines Rapids, Mississippi River, two hundred and thirty thousand dollars. Des Moine Rapids.

For the improvement of the harbor at Baltimore, Maryland, seventy-five thousand dollars. Baltimore.

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Rappahannock River.	For the improvement of the Rappahannock River, Virginia, ten thousand dollars.
James River.	For the improvement of James River, Virginia, sixty thousand dollars.
Cape Fear River.	For the improvement of Cape Fear River, North Carolina, one hundred and thirty-two thousand five hundred dollars.
French Broad River.	For the improvement of the French Broad River between Brevard and the Buncombe County line, North Carolina, ten thousand dollars.
Pamlico River	For the improvement of Pamlico River, North Carolina, fifteen thousand dollars.
Hiawassee River.	For the improvement of the Hiawassee River, Tennessee, ten thousand dollars.
Cumberland River.	For the improvement of Cumberland River above the city of Nashville, Tennessee, from Nashville to the Kentucky line, fifteen thousand dollars; and thence to the foot of Smith's Shoals, ten thousand dollars; and for Smith's Shoals, twenty-five thousand dollars; and from Smith's Shoals to the Falls of the Cumberland, two thousand dollars.
Great Kanawha River.	For the improvement of the Great Kanawha River, West Virginia, including the purchase of, and full payment for, sites for dams and locks, between the Great Falls and the Ohio River, not exceeding fifteen thousand dollars, two hundred and seventy thousand dollars
Little Kanawha River.	For removal of Beaver and Nailor Bend rocks, and for cleaning out snags and fallen trees in the little Kanawha, West Virginia, seven thousand and three hundred dollars.
Savannah.	For the improvement of the harbor at Savannah, Georgia, sixty-two thousand dollars.
Chattahoochie and Flint Rivers.	For the improvement of the Chattahoochie and Flint Rivers, Georgia, twenty thousand dollars.
Cypress Bayou.	For continuing the work of dredging and removing obstructions to navigation in Cypress Bayou, Texas, thirteen thousand dollars.
Sabine Pass, Sabine and Neches Rivers.	For the improvement at Sabine Pass, and for improvement of Blue Buck Bar and Sabine Bay, and for deepening the channel over the bar at the mouth of the Sabine River, and for deepening of the channel over the bar at the mouth of Neches River, where these rivers enter Sabine Bay, thirty-eight thousand dollars.
Pass Cavallo.	For the improvement of Pass Cavallo, inlet to Matagorda Bay, Texas, twenty thousand dollars.
Coosa River.	For the improvement of the Coosa River, Georgia and Alabama between Rome and the Selma, Rome and Dalton Railroad bridge, thirty thousand dollars.
Ouchita River.	For the improvement of Ouchita River, Arkansas and Louisiana, twelve thousand dollars.
Cedar Keys.	For the improvement of the harbor at Cedar Keys, Florida, ten thousand dollars.
Lower Willamette and Columbia Rivers.	For the improvement of the Lower Willamette and Columbia Rivers from Portland, Oregon, to the sea, twenty thousand dollars.
Upper Willamette River.	For the improvement of the Upper Willamette River, Oregon, twenty thousand dollars.
Upper Columbia River.	For the improvement of the Upper Columbia, including Snake River, fifteen thousand dollars.
Oakland Harbor.	For the improvement of Oakland Harbor, California, to be applied to finishing training walls and dredging between them, seventy-five thousand dollars.
San Joaquin River.	For the improvement of San Joaquin River, California, twenty thousand dollars.
Delaware River.	For the improvement of the Delaware River below Petty's Island, forty thousand dollars.
Red River.	For removing raft in Red River and closing Tone's Bayou, Louisiana, thirty-five thousand dollars.
Little Sodus Bay.	For the improvement of the harbor at Little Sodus Bay, New York, five thousand dollars.
Schuylkill River.	For the improvement of the Schuylkill River, Pennsylvania twenty thousand dollars.
Bridgeport.	For the improvement of the harbor at Bridgeport, Connecticut, ten thousand dollars.
Southport.	For improvement of the harbor at Southport, Connecticut, five thousand dollars.
Black Lake.	For the improvement of the harbor at Black Lake, Michigan, fifteen thousand dollars.
Saugatuck.	For the improvement of the harbor at Saugatuck, Michigan, three thousand dollars.

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For the improvement of the harbor at Saint Joseph's, Michigan, twelve thousand dollars. — Saint Joseph's.

For the improvement of the harbor at Manitowoc, Wisconsin, eight thousand dollars. — Manitowoc.

For the improvement of the harbor at Sheboygan, Wisconsin, six thousand dollars. — Sheboygan.

For the improvement of the harbor at Port Washington, Wisconsin, eight thousand dollars. — Port Washington.

For the improvement of the harbor at Oswego, New York, ninety thousand dollars. — Oswego.

For the improvement of Hudson River, fifty thousand dollars. — Hudson River.

For the improvement of the Appomattox River, Virginia, thirty thousand dollars. — Appomattox River.

For the improvement of the South Branch of Elizabeth River, Virginia, five thousand dollars. — South Branch Elizabeth River.

For the improvement of Nansemond River, Virginia, five thousand dollars. — Nansemond River.

For the improvement of the Yazoo River, Mississippi, fifteen thousand dollars. — Yazoo River.

For the improvement of White River at Buffalo Shoals, Arkansas, ten thousand dollars. — White River.

For the improvement of Perquimons River, North Carolina, two thousand five hundred dollars. — Perquimons River.

For the improvement of the harbor at Charleston, South Carolina, ten thousand dollars. — Charleston.

For the improvement of the Etowah River, Georgia, ten thousand dollars. — Etowah River.

For the improvement of the Ocmulgee River, Georgia, fifteen thousand dollars. — Ocmulgee River.

For the improvement of New River from the lead-mines in Wythe County, Virginia, to the mouth of Green-brier River, West Virginia, fifteen thousand dollars. — New River.

For the improvement of the harbor at Norfolk, Virginia, thirty-five thousand dollars. — Norfolk.

For the improvement of the Warrior and Tombigbee River, Alabama, fifteen thousand dollars. — Warrior and Tombigbee Rivers.

For the improvement of the Choctawhatchie River, Florida and Alabama, five thousand dollars. — Choctawhatchie River.

For continuing the improvement on the outer bar at Galveston, Texas, one hundred and forty-two thousand dollars. — Galveston.

For the improvement of the Missouri River above the mouth of the Yellowstone, twenty thousand dollars. — Missouri River.

For the improvement of Chester River at Kent Island Narrows, Maryland, five thousand dollars. — Chester River.

For the improvement of the Wicomico River, Maryland, five thousand dollars. — Wicomico River.

For the improvement of the harbor at Michigan City Indiana, thirty five thousand dollars. — Michigan City

For the improvement of the channel of the Mississippi River opposite the city of Saint Louis, Missouri, by the construction of a low dam across the channel east of Arsenal Island, known as Cahokia Chute, and in the revetment of said island, twenty-nine thousand, six hundred dollars. — Mississippi River.

For the improvement of the Rush Chute and the harbor of Burlington, Iowa, ten thousand dollars. — Burlington.

For the improvement of the harbor at Fort Madison, Iowa, ten thousand dollars. — Fort Madison.

For the improvement of the harbor at South Haven, Michigan, ten thousand dollars. — South Haven.

For the improvement of Saint Mary's River and Saint Mary's Falls Canal, Michigan, one hundred and thirty thousand dollars. — Saint Mary's River.

For the improvement of the harbor at Cheboygan, Michigan, ten thousand dollars. — Cheboygan.

For the improvement of Au Sable River, Michigan, one thousand dollars. — Au Sable River.

For the improvement of the Saginaw River, Michigan, eleven thousand dollars. — Saginaw River.

For the improvement of the harbor at Milwaukee, Wisconsin, twenty-six thousand dollars. — Milwaukee.

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Kenosha. For the improvement of the harbor at Kenosha, Wisconsin, eight thousand dollars.

Mississippi River. For the improvement of the Mississippi River above the Falls of Saint Anthony, twenty thousand dollars; no part of which shall be expended upon the Falls of Saint Anthony.

Monroe. For the improvement of the harbor at Monroe, Michigan, five thousand dollars.

Charlevoix. For the improvement of the harbor at Charlevoix, Michigan, ten thousand dollars.

Thunder Bay. For the improvement of the harbor at Thunder Bay, Michigan, four thousand five hundred dollars.

Ashtabula. For the improvement of the harbor at Ashtabula, Ohio, five thousand dollars.

Port Clinton. For the improvement of the harbor at Port Clinton, Ohio, five thousand dollars.

Fairport. For the improvement of Fairport Harbor, Ohio, five thousand dollars.

Black River. For repair of piers at mouth of Black River, Ohio, six thousand dollars.

Fox and Wisconsin Rivers. For the improvement of the Fox and Wisconsin Rivers, two hundred and seventy thousand dollars.

Erie. For the improvement of the harbor at Erie, Pennsylvania, forty thousand dollars.

Block Island. For the improvement of the breakwater at Block Island, Rhode Island, forty thousand dollars.

Boston. For the improvement of the Boston Harbor, Massachusetts, fifty thousand dollars.

Little Narragansett Bay. For the improvement of Little Narragansett Bay, Rhode Island and Connecticut, five thousand dollars.

Kennebunk River. For the improvement of the Kennebunk River, Maine, five thousand dollars.

Belfast. For the improvement of Belfast Harbor, Maine, five thousand dollars.

Roundout. For the improvement of the harbor at Roundout, New York, thirty thousand dollars.

Port Jefferson. For the improvement of the harbor at Port Jefferson, Long Island, New York, six thousand dollars.

Staten Island Channel. For the improvement of the channel between Staten Island and New Jersey, ten thousand dollars.

Provincetown. For the improvement of the harbor at Provincetown, Massachusetts, four thousand dollars.

New Castle. For the construction of piers of Ice Harbor, and removing obstructions at New Castle, Delaware, twelve thousand dollars.

Harbor of Refuge, Lake Huron. For the improvement of the Harbor of Refuge, Lake Huron, Michigan, including removal of the wreck of the "City of Buffalo," seventy-five thousand dollars.

Chippewa River. For the improvement of the Chippewa River, Wisconsin, ten thousand dollars.

Wabash River. For the improvement of the Wabash River, Indiana, seventy thousand dollars.

Calumet. For the improvement of the harbor at Calumet, Illinois, twenty thousand dollars.

Illinois River. For the improvement of the Illinois River, Illinois, forty thousand dollars.

Red River of the North. For the improvement of the Red River of the North, Minnesota, ten thousand dollars.

Upper Mississippi River. For the improvement of the Upper Mississippi River, thirty thousand dollars; and seven thousand dollars thereof may be applied, if the Secretary of War shall deem it for the public interest, in constructing the necessary machinery used in Captain Edward Bell's process for building wing-dams, and applying said process in the improvement of said river.

Bell's wing-dams.

Rock Island Rapids. For the improvement of Rock Island Rapids, Mississippi River, twenty-five thousand dollars.

Mississippi, Missouri, and Arkansas Rivers. For the improvement of the Mississippi, Missouri, and Arkansas Rivers, one hundred thousand dollars: *Provided*, That ten thousand dollars thereof shall be expended for removing the bar at Fort Smith, Arkansas: *And provided further*, That forty thousand dollars of the above sum shall be expended on the Missouri River, including improvements opposite Saint Joseph, Missouri, and at Nebraska City.

Proviso.

Mississippi River. For the improvement of the Mississippi River between the mouths of the Illinois and Ohio Rivers, (fifteen thousand dollars of which are to be expended between the mouths of the Illinois and Missouri Rivers, and

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thirty thousand dollars of which are to be expended between the foot of Dickey Island and the mouth of the Ohio River, and five thousand dollars of which are to be expended between islands Number Fourteen and Number Fifteen near the town of Kaskasia, Illinois,) two hundred thousand dollars. How expended.

For removal of a bar in the Mississippi River opposite Dubuque, Iowa, fifteen thousand dollars. Mississippi River.

For the improvement of the Ohio River, one hundred and seventy-five thousand dollars. Ohio River.

For the annual expense of gauging the waters of the Lower Mississippi and its tributaries and for continuing observations of the rise and fall of the same, as required by joint resolution of February twenty-first, eighteen hundred and seventy-one, five thousand dollars. Lower Mississippi, gauging waters. 1871, Res. 40. 16 St., 598. R. S., § 252, p. 1021.

For the improvement of the Tennessee River, two hundred and seventy thousand dollars; fifteen thousand dollars of which are to be expended above Chattanooga, and the remaining two hundred and fifty-five thousand dollars are to expended upon Muscle Shoals. Tennessee River.

To ascertain in current and next fiscal years, as required by act of March third, eighteen hundred and seventy-five, the depth of water and width of channel secured and maintained, from time to time, by James B. Eads, at South Pass of the Mississippi River, and to enable the Secretary of War to report during the construction of the work the payments made from time to time and the probable times of other payments, and to report during the construction of the work all important facts relating to the progress of the same, materials used, and the character and permanency with which the said jettee and auxiliary works are being constructed, fifteen thousand dollars. South Pass of Mississippi River, depth of water. 1875, ch. 134, 18 Stat., 463.

For the construction of a canal around the cascades of the Columbia River in the State of Oregon, ninety thousand dollars; of which amount the Secretary of War is authorized to expend so much as, in his judgment, may be necessary and proper to secure title and right of way for canal and locks, not exceeding the sum of ten thousand dollars; and whenever, in the prosecution of the said work, it shall have become necessary to obtain the right of way over any lands for the said canal and locks, the Secretary of War shall take possession of and use the said lands, after having purchased the same, or, in case the said lands cannot be purchased for a reasonable price, then after having paid for the same, or secured the value thereof, which value may be ascertained in the mode provided by the laws of Oregon for the condemnation of lands for public uses in that State. The Department of Justice shall represent the interests of the United States in any legal proceedings under this act to obtain the right of way for said canal. Columbia River Canal. Proviso.

For the improvement of the harbor at Racine, Wisconsin eight thousand dollars. Racine.

For the continuing of the work on the ship-channel in Galveston Bay, seventy-two thousand dollars; to be expended between Red Fish Bar and Morgan's Point. Galveston Bay.

For the improvement of the mouth of the Mississippi River, one hundred thousand dollars: *Provided*, That this appropriation shall not be available whenever and so long as there shall be an open channel of eighteen feet of water, at mean tide, to and from the sea through the South Pass of the Mississippi River to the port of New Orleans. Mouth of Mississippi River. Proviso.

It shall be the duty of the Secretary of War to apply the moneys herein appropriated as far as may be by contract, except when specific estimates cannot be made for the particular work, or where, in the judgment of said Secretary, the work cannot be contracted at prices advantageous to the Government, and except the appropriations made for examinations and surveys; and such contracts shall be made after sufficient public advertisement for proposals, in such form and manner as the Secretary of War shall prescribe; and such contracts shall be made with the lowest responsible bidders therefor, accompanied by such securities as the Secretary of War shall require. How appropriations to be applied and expended.

SEC. 2. That the Secretary of War is hereby directed to cause a survey for a ship-channel through Galveston Bay, beginning at twelve feet water in the mouth of the San Jacinto River and running out of the mouth of said river east of Morgan's Point to the present channel, through Red Fish Bar; thence through the same, extending through Galveston Harbor, passing west of Half Moon Shoals and Pelican Island, and to Survey of ship-channel in Galveston Bay.

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twelve feet water in Galveston Channel; and to cause an estimate of the cost of the same to be made and of the comparative merits of the same, with the route to the head of Bolivar Channel; and of the effects of the completion of each of said channels on the Galveston Harbor as to shoaling or deepening the same, and report the same to Congress by the first day of December, eighteen hundred and seventy-six, the cost thereof not to exceed ten thousand dollars, to be paid out of the forty thousand dollars hereinafter appropriated. And the sum of forty thousand dollars is hereby appropriated for incidental repairs of harbors for which there is no special appropriation provided for by law, and for examination and survey of such rivers and harbors, as in the judgment of the Secretary of War, will subserve the general interests of commerce.

Appropriation for repairs and surveys.

Reports by Secretary of War of necessary legislation and unlawful use of piers, etc.

SEC. 3. That the Secretary of War is hereby directed to report to Congress on the first Monday of December next what legislation, in his opinion, is necessary to protect the breakwaters, piers, and other public works constructed by the United States against trespasses upon or injury thereto; and the Secretary of War is hereby directed to report to Congress at its next session all the instances in the United States in which piers, breakwaters, or other structures or works built or made by the United States in aid of commerce or navigation, are used, occupied, or injured by a corporation or an individual, and the extent and mode of such use, occupation, or injury, and the facts touching the same. Any person who shall wilfully and unlawfully injure any pier, breakwater, or other work of the United States for the improvement of rivers or harbors or navigation in the United States, shall, on conviction thereof, be punished by a fine not exceeding one thousand dollars.

Approved, August 14, 1876.

Aug. 15, 1876.

CHAP. 287.—An act making appropriations for the legislative, executive, and judicial expenses of the Government for the year ending June thirtieth, eighteen hundred and seventy-seven, and for other purposes.

Appropriations for legislative, executive, and judicial expenses.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, in full compensation, for the service of the fiscal year ending June thirtieth, eighteen hundred and seventy-seven, for the objects hereinafter expressed, namely:

* * * * * * *

PUBLIC BUILDINGS AND GROUNDS.

Salaries.

For clerk in the Office of Public Buildings and Grounds, one thousand four hundred dollars.

For messenger in the same office, eight hundred and forty dollars.

For landscape gardener, one thousand eight hundred dollars.

For the laborer in charge of the water-closets in the Capitol, seven hundred and twenty dollars.

For a foreman and laborers employed in the public grounds, fifteen thousand four hundred and fifty-six dollars.

For two laborers in the Capitol, one thousand four hundred and forty dollars.

For furnace-keeper in charge of heating apparatus under the old hall of the House of Representatives, eight hundred and sixty-four dollars.

Architect of Capitol to have charge of Capitol building.

For the person in charge of the heating apparatus of the Library of Congress and other steam-heating apparatus in the central building, eight hundred and sixty-four dollars: *Provided*, That the Architect of the Capitol shall have the care and superintendence of the Capitol including, lighting, and shall submit through the Secretary of the Interior, estimates thereof: *And provided further*, That all the duties relative to the Capitol building heretofore performed by the Commissioner of public buildings and grounds, shall hereafter be performed by the Architect of the Capitol, whose office shall be in the Capitol building.

Office

Executive Mansion, employés.

For the following employees at the Executive Mansion, namely: For furnace-keeper, eight hundred and sixty-four dollars; one night-watchman, at nine hundred dollars; one night usher, at one thousand two hundred dollars; two day-ushers, one at the President's door and one at

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the door of the Secretary at one thousand two hundred dollars each; and two door-keepers at twelve hundred dollars each; in all, seven thousand seven hundred and sixty-four dollars.

For two draw-keepers for Navy-Yard and Upper Bridges, and for fuel, oil, and lamps, one thousand six hundred dollars. Draw-keepers.

For watchman in Franklin Square, seven hundred and twenty dollars. Watchmen in grounds.

For watchman at La Fayette Square, seven hundred and twenty dollars.

For two watchmen in Smithsonian Grounds, at seven hundred and twenty dollars each, fourteen hundred and forty dollars.

For one bridge-keeper at Chain Bridge, seven hundred and twenty dollars. Bridge-keeper.

For contingent and incidental expenses, five hundred dollars. Contingent expenses.

* * * * * * *

IN THE OFFICE OF THE CHIEF OF ENGINEERS.—One chief clerk, at two thousand dollars; four clerks of class four; three clerks of class three; three clerks of class two; three clerks of class one; one messenger; two laborers; in all, twenty-four thousand and eighty dollars. Engineer Bureau.

For contingent expenses, namely: For stationery, office furniture, miscellaneous and incidental expenses, including purchase of professional books and maps, three thousand dollars.

* * * * * * *

SEC. 8. That for the purpose of defraying the expenses of a survey of the Union Pacific and Central Pacific Railways between Council Bluffs, Iowa, and Sacramento, California, to be made in pursuance of the resolution of the House of Representatives passed the twelfth day of July, eighteen hundred and seventy-six, ten thousand dollars. Survey of Union Pacific and Central Pacific Railways. *Post*, p. 217.

* * * * * * *

Approved, August 15, 1876.

Aug. 15, 1876.

[No. 22.] Joint resolution amending the Eighth Section of the act "making appropriations for the legislative, executive, and judicial expenses of the Government for the year ending June thirtieth, eighteen hundred and seventy-seven, and for other purposes." 1876, ch. 287, *Ante*, p. 169, amended.

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That section eight of the act making appropriations for the legislative, executive, and judicial expenses of the Government for the year ending June thirtieth, eighteen hundred and seventy-seven, and for other purposes, be amended by striking out the words "twelfth day of July," and inserting, in lieu thereof, the words "nineteenth day of July."

Approved, August 15, 1876.

FORTY-FOURTH CONGRESS, FIRST SESSION.

CONGRESS OF THE UNITED STATES,
In the House of Representatives, July 19, 1876.

Mr. JENKS submitted the following, which was agreed to:

Whereas it is alleged that the measurements of the distances on the Union Pacific and Central Pacific Railroads upon which bonds were issued by the Government to the companies owning said railroad, was hastily and inaccurately made; therefore,

Resolved by the House of Representatives, That the Secretary of War be requested to detail a sufficient force from the Engineer Corps of the Army to make a careful and exact survey of the distances of said roads between Omaha and Sacramento, distinguishing between the sections for which bonds were issued to the companies at different rates, exhibiting the number of miles at each rate, designating the points between which the different rates were charged, and report the result of the survey to this House at the commencement of the next session of Congress.

Attest:

GEO. M. ADAMS, *Clerk*.

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Aug. 15, 1876. CHAP. 303.—An act to authorize the construction of a bridge across the Missouri River at or near Sioux City, Iowa.

Sioux City Bridge Company may construct bridge across Missouri River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Sioux City Bridge Company, a corporation organized for that purpose under the general corporation laws of the State of Iowa, or its assigns, to construct, under and subject to the conditions and limitations hereafter provided, a bridge across the Missouri River at or near Sioux City, Iowa, and lay on and over said bridge railway tracks, for the more perfect connection of any and all railways that now are, or which may hereafter be, constructed to the Missouri River at or near Sioux City, or to the river on the opposite side of the same near Sioux City, and build, erect, and lay on and over said bridge ways for wagons, vehicles of all kinds, and for the transit of animals, and to provide ways for foot-passengers, and to keep up and maintain and operate said bridge for the purposes aforesaid; and that when said bridge is constructed all

Use of by railways.

trains of all railroads terminating at said river, and on the opposite side thereof, at or near Sioux City, Iowa, shall be allowed to cross said bridge for reasonable compensation, to be made to the owners of the same,

Tolls.

under the limitations and conditions hereinafter named. The owners of said bridge may also charge and receive reasonable compensation or tolls for the transit over said bridge of all wagons, carriages, vehicles,

Proviso.

animals and foot-passengers: *Provided*, That Congress may at any time prescribe such rules, regulations, and rates of toll for transit and transportation over said bridge as may be deemed proper and reasonable.

How to be built.

SEC. 2. That any bridge built under the provisions of this act may, at the option of the person or persons or corporation building the same, be built as a draw-bridge, with a pivot or other form of draw, or with

Proviso.

unbroken or continuous spans: *Provided*, That if the same shall be made of unbroken continuous spans, it shall not be, in any case, of less elevation than fifty feet above extreme high-water mark, as understood at the point of location, to the lowest part of the superstructure, with straight girders, nor shall the spans of said bridge be less than three hundred feet in the clear at low-water mark; and the piers of said bridge shall be parallel with the current of the river; and the main span shall be

Proviso.

over the main channel of the river: *And provided also*, That if a bridge shall be built under this act as a draw-bridge, the same shall be constructed as a pivot draw-bridge, with a draw over the main channel of the river at an accessable and navagable point and with spans of not less than one hundred and sixty feet in length in the clear on each side of the central or pivot pier of the draw; and the next adjoining spans to the draw shall not be less than two hundred and fifty feet, and said spans shall not be less than ten feet above extreme high-water mark, measuring to the lowest part of the superstructure of the bridge; and the piers of said bridge shall be parallel with the current of the river:

Proviso.

And provided also, That said draw shall be opened promptly upon reasonable signal, without unnecessary delay: *And provided further*, That

Proviso.

the corporation building said bridge may, subject to the approval of the Secretary of War, enter upon the banks of said river, either above or below the point of location of said bridge, and confine the flow of the

Permanent channel may be made.

water to a permanent channel, and to do whatever may be necessary to accomplish said objects, but shall not impede or obstruct the navigation of said river, and shall be liable in damages for all injuries to private property; and all plans for such works or erections upon the banks of the river shall first be submitted to the Secretary of War for his ap-

Proviso.

proval: *And provided further*, That if said company shall elect to construct a pile and pontoon bridge in lieu of that described above, the Secretary of War may, if he deem it advisable and not inconsistent with the free navigation of said river, authorize said company to construct such bridge as a pile or pontoon bridge, subject to the restrictions and requirements relating to the construction thereof contained in the act

1874, ch. 224, 18 Stat., 62.

entitled "An act to legalize and establish a pontoon-bridge across the Mississippi river at Prairie du Chien" approved June sixth, eighteen hundred and seventy-four, accept that in the bridge herein authorized one draw only shall be required, which shall not be less than four hun-

Proviso.

dred feet in width in the clear: *And provided further*, That any bridge built under the provisions of this act shall be at right-angles to the current of the river.

Not to obstruct navigation.

SEC. 3. That no bridge shall be erected or maintained under the authority of this act which shall at any time substantially or materially obstruct the free navigation of said river; and no bridge shall be com-

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menced or built under this act until the location thereof and the plans and specifications for its construction shall have been submitted to, and approved by, the Secretary of War; and any change in the plan of such construction or any alteration in the bridge after its construction shall be subject to the like approval; and whenever said bridge shall, in the opinion of the Secretary of War, substantially obstruct the free navigation of said river, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction; and all such alterations shall be made, and all such obstructions be removed, at the expense of the owner or owners of said bridge; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of the Missouri River at or near the crossing of said bridge caused or alleged to be caused thereby, the cause shall be commenced and tried in the district courts of either judicial district of Iowa or Nebraska in which the said bridge or any portion of such obstruction touches.

Approval of plans.

Alterations.

Litigation for obstruction, where tried.

SEC. 4. That any bridge built under this act and according to its limitations shall be a lawful structure, and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transportation over the same of the mails, troops, and munitions of war of the United States than the rate per mile paid for their transportation over the railroads or public highways leading to such bridge. Such lights shall be kept upon said bridge as the Light-House Board shall direct, and said bridge shall moreover be provided with all proper safeguards for the security of person and property.

Declared lawful structure and post-route.

Charges for transportation for United States.

Lights and safeguards.

SEC. 5. That Congress may at any time alter, amend, or repeal this act.

Right to amend.

Approved, August 15, 1876.

CHAP. 306.—An act to amend an act entitled "An act authorizing the repavement of Pennsylvania Avenue."

Aug. 15, 1876.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That that part of section five of an act entitled "An act authorizing the repavement of Pennsylvania Avenue" approved July nineteenth, eighteen hundred and seventy-six, which reads as follows: "*Provided* That said pavement shall be fully completed and ready for use December first eighteen hundred and seventy-six" be, and the same is hereby amended so as to read as follows: "*Provided*, That the said pavement shall be fully completed and ready for use January fifteenth, eighteen hundred and seventy-seven."

1876, ch. 231, § 5 *Ante*, p. 93. Amended.

Pavement of Pennsylvania avenue, when to be completed.

Approved, August 15, 1876.

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APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS.

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APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS.

APPENDIX A.

ANNUAL REPORT OF LIEUTENANT-COLONEL GEORGE THOM, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Portland, Me., July 13, 1876.

GENERAL: I have the honor to transmit herewith my annual reports of operations for the fiscal year ending June 30, 1876, on the several river and harbor improvements, as well as the examinations and surveys of rivers and harbors, under my charge, in the States of Maine, New Hampshire, and Massachusetts.

Very respectfully, your obedient servant,

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

A 1.

IMPROVEMENT OF SAINT CROIX RIVER, ABOVE THE "LEDGE," MAINE.

The following appropriations have been made by Congress for the improvement of this river, viz:

By act approved March 2, 1867	$15,000 00
By act approved March 3, 1873	10,000 00
By act approved June 23, 1874	10,000 00
Total	35,000 00

The act of March 2, 1867, contained the proviso that—

The province of New Brunswick contribute and pay to the proper disbursing officer a like sum for said purpose; said payment being made on condition that in no event shall the province of New Brunswick be called upon for more than half the sum actually expended for said purpose.

In July, 1873, information was received by the Department from the minister of public works of the Dominion of Canada that $25,000 had been appropriated by Parliament—

For the removal of slabs, saw-dust, and other obstructions in the Saint Croix River, which runs between the province of New Brunswick and the State of Maine.

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An accurate survey was made in 1873, under my direction, by Assistant Engineer Mr. Sophus Haagensen, of this river from the "Ledge" up to the toll-bridge between Calais and Saint Stephen's, the head of navigation, and a project for the improvement of this river, with an estimate of its cost, was submitted to both governments.

On referring to my estimate submitted to the Department, in a special report dated March 25, 1874, it is seen that about 235,000 cubic yards of slabs, edgings, &c., would have to be excavated, in order to obtain a channel 200 feet wide and 9 feet deep at mean low-water (giving 29 feet at mean high-water) up to Todd's Ledge, and 100 feet wide with same depth thence up to the toll-bridge, the estimated cost of which is $200,000.

Now, as these deposits in the channel have been caused solely by the saw-mills at Calais, Saint Stephen's, and above, and as there does not appear to be any law or authority strong enough to prevent the continuance of this evil, it has been decided by the two governments (see correspondence accompanying my annual report for the fiscal year ending June 30, 1874) to suspend this improvement until they shall become satisfied that there will be no further deposition of the "waste" from the saw-mills above, as otherwise there is no guarantee that the river, if now improved, would remain in a state of efficiency, but would, instead, be closed again, and require further expenditure.

The attention of Congress is again respectfully asked to this matter, and to the necessity of some general law to protect from injury and obstructions all navigable waters under the control of the United States, and for the improvement of which Congress has already made, or may hereafter see fit to make, appropriations.

This river, throughout its whole extent, forms a part of the international boundary, and that portion of it for which improvements are projected lies within the collection district of Passamaquoddy, the nearest port of entry being at Calais, Me.

The light-house nearest thereto is at Dochet's Island, in Saint Croix River, about 8 miles below Calais, and the nearest fort is Fort Sullivan, at Eastport, Me., about 30 miles below Calais.

The amount of duties collected at the port of Calais during the year ending December 31, 1875, was $15,678.68, as stated by the deputy collector of customs at that port.

Money statement.

Amount available July 1, 1875	$34,185 58
Amount available July 1, 1876	34,185 58
Amount (estimated) required for completion of existing project on the part of the United States	65,000 00

A 2.

IMPROVEMENT OF MACHIAS RIVER, MAINE.

The following appropriations have been made for the improvement of this river, viz:

By act of Congress approved March 3, 1873	$12,000 00
By act of Congress approved June 23, 1874	10,000 00
By act of Congress approved March 3, 1875	10,000 00
Total	32,000 00

The foregoing appropriations have been made on an estimate submitted in my report of December 14, 1872, to the Department on the survey of

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this river, made with a view to its improvement, which estimate is as follows, viz:

1. Opening a channel from the draw-bridge up to Machias Falls, at the head of navigation, (a distance of about 3 miles,) so as to have a depth of 6 feet at mean low-water, (giving 19.3 feet at mean high-water) for a width of 150 feet, requiring the excavation of 65,500 cubic yards of slabs, edgings, saw-dust, &c., at 50 cents	$32,750 00
2. The removal of Middle Rock, lying in front of the wharves at Machias, to a depth of 1 foot below the plane of mean low-water, requiring 2,095 cubic yards of excavation, at $5 per cubic yard	10,475 00
Adding for engineering expenses and other contingencies, say	4,775 00
Total	48,000 00

In the prosecution of this work it has been deemed advisable to modify the project first submitted (as above) by diminishing the proposed channel to a width of 100 feet, except at the bends, and not extending the excavation of Middle Rock to a greater depth than ½ a foot below the plane of mean low-water. By this modification the estimate has been reduced as follows, viz:

1. The removal of Middle Rock, 1,350 cubic yards, at $6.75 per cubic yard in *situ*, the price contracted for under the appropriation of March 3, 1873	$9,112 50
2. 17,840 cubic yards of dredging on shoal between the Middle Ground and Middle Rock above, together with shoal next above draw-bridge, completed in July, 1875, at 75 cents per cubic yard *in situ*, the price contracted for under the appropriation of June 23, 1874, and with unexpended balance of former appropriation	10,704 00
3. 20,000 cubic yards of dredging* at and near the Middle Ground, contracted for May 13, 1875, by Mr. Augustus R. Wright, under the appropriation of March 3, 1875, at 45 cents per cubic yard, measured *in situ*, the same to be completed on or before 30th of September, 1876	9,000 00
Contingencies, say	3,183 50
Total	32,000 00

Which is the amount that has already been appropriated by Congress for this work.

As the shoals in this river have been caused chiefly by slabs, edgings, and saw-dust, thrown into the river from the saw-mills at and above Machias Falls, they will of course continue to be formed so long as the mills shall be permitted, as at present, to throw their "waste" into the river; so that the improvement of the shoals now being made will doubtless be only temporary in its efficiency. But even if otherwise, it is believed that the improvements now projected, and for the completion of which the funds now available are sufficient, will fully answer the wants of the commerce of this river.

It is therefore recommended that no further appropriation be made for this work.

It is respectfully recommended that the attention of Congress be called to this matter, as well as to that of the Saint Croix River, with a view to protecting from injury and obstruction by suitable legislation these and all other navigable waters under the control of the United States for the improvement of which appropriations have been or hereafter may be made by the United States Government.

Money statement.

Amount available July 1, 1875	$22,011 53
Amount expended during the fiscal year ending June 30, 1876	12,661 03
Amount available July 1, 1876	9,350 50

*The dredging under contract made with Mr. Augustus R. Wright, May 13, 1875, was commenced July 5, 1876, and is to be completed on or before the 30th of September, 1876.

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A 3.

IMPROVEMENT OF PENOBSCOT RIVER, ABOVE HAMPDEN, MAINE.

The work projected for the improvement of this river above Hampden, as estimated for in my annual report for the year ending June 30, 1871, which was based upon the most reliable data had at that time, consisted—

1. In the enlargement and straightening of its channel through the several shoals for a distance of three and a half miles below Bangor, so as to have a width of not less than 200 feet, and a depth of 12 feet at low-water (or 25 feet at high-water) in the lowest stages of the river, giving about 15 feet at low-water in its ordinary stages, requiring about 100,000 cubic yards of dredging, the estimated cost of which was	$100,000 00
2. In breaking up and removing all the sunken rocks in the harbor of Bangor down to the level of the general bed of the river, including Independence Rock, ledge near steamboat-wharf, Gulliver's Rock, and the ledge near Green's Pier, in all about 1,525 cubic yards, which, at an estimated cost of $25 per cubic yard, amounted to	38,125 00
Adding for contingencies, say	16,875 00
Total	155,000 00
Since the above estimates were made it has been decided, in accordance with the project submitted April 2, 1873, to include in the improvement of this harbor the removal of Green's Pier and the ledge upon which it rests, the cost of which, (including contingencies,) as since contracted for, will amount to about	17,000 00
Making a total of	172,000 00

For these improvements the following appropriations have been made, to date, by Congress, viz:

By act approved July 11, 1870	$15,000 00
By act approved March 3, 1871	50,000 00
By act approved June 10, 1872	40,000 00
By act approved March 3, 1873	20,000 00
By act approved June 23, 1874	20,000 00
By act approved March 3, 1875, which provides that $10,000 of this amount shall be expended at or near Bucksport Narrows, for which no project or estimate had been made	25,000 00
Total	170,000 00

Of which amount $160,000 only can be charged to the improvement above Hampden, as heretofore projected and estimated for.

Of the amount appropriated as above, ($170,000,) there had been expended up to the 1st of July, 1875, the sum of $101,114.82, leaving then available the sum of $68,885.18, of which amount the act of March 3, 1875, provided that $10,000 should be expended for the improvement of the river at or near Bucksport Narrows, which had not been included in the projects and estimates previously submitted to the Department; so that there remained available for the improvement at and near Bangor the sum of $58,885.18.

As stated in my annual report for the fiscal year ending June 30, 1875, an additional appropriation of $12,000 would be necessary for completing all the improvements now projected for the improvement of this river at and near Bangor.

The progress made in the improvement of this river up to the 1st of July, 1875, was as follows, viz:

Independence Rock, Gulliver's Rock, ledge near the steamboat wharf, ledge off Dole's planing-mill wharf, and the ledge near Green's Pier were entirely removed, and some progress made in the removal of Green's Pier and Ledge, (containing about 460 cubic yards,) under a contract made June 21, 1873, with Mr. George A. Bailey, of Boston, Mass. Under the unfinished contract made May 27, 1870, with Mr. A. Boschke, about 20,000

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cubic yards of dredging was done in 1870–'71, at the first and second bars. A contract made May 31, 1873, with Messrs. Curtis, Fobes & Co., of Portland, Me., for improving by dredging the channels at Bars Nos. 2 and 3, in removing the shoal near Green's Pier, and for dredging in the Middle Ground Bar, was completed in October, 1874, 25,150 cubic yards having been dredged under that contract.

During the fiscal year ending June 30, 1876, the following work has been done, viz:

Operations have been continued by Mr. George A. Bailey, under his contract of June 21, 1873, for the removal of Green's Pier Ledge. At the close of last season (November, 1875) he had removed about 342 cubic yards of the ledge, leaving about 118 cubic yards still to be removed for its completion. The continued freshets in the spring of 1876 prevented his resuming work before the 15th of June, so that it is not probable that he will complete the work before the end of August, 1876.

Under the appropriation of June 23, 1874, a contract was made August 29, 1874, with Messrs. Curtis, Fobes & Co., of Portland, Me., for about 25,000 cubic yards of dredging on the Middle Ground Bar. Work was commenced under this contract in June, 1875, and on the 18th of October, 1875, at the close of the season's work, 8,222 cubic yards of dredging had been done under that contract. Arrangements have been made for resuming this work about the 10th of July, and it is expected that it will be completed on or before the 30th of September next.

Under the appropriation made by act of March 3, 1875, by which it was provided that only $15,000 should be applied to the continuation of the improvement of the river at Bangor, a contract was made May 13, 1875, with Mr. Augustus R. Wright, of Geneva, N. Y., the lowest bidder, at 50 cents per cubic yard, for 40,000 cubic yards, more or less, of dredging, measured *in situ*, on the Middle Ground Bar, in Bangor Harbor, to be completed on or before the 15th of November, 1876. Arrangements have been made for commencing this work about the 10th of July, 1876.

In the dredging operations of 1875, a ledge was discovered in this new channel, which it will be necessary to have removed, and for which no estimate has hitherto been submitted. But, to provide for this, it has been decided, with the sanction of the Department, to excavate this channel to a depth of 11 feet (instead of 12) at low-water, in the lowest stages of the river, giving 14 feet at ordinary low-water, which is deemed sufficient for the wants of commerce. With this modification, and owing to the greatly diminished quantity of ledge excavation resulting therefrom, it is not thought that another appropriation will be needed for completing all the projected improvements of this river in addition to the $12,000 asked for in my annual report for the fiscal year ending June 30, 1875.

IMPROVEMENT AT AND NEAR BUCKSPORT NARROWS.

By the act of March 3, 1875, making an appropriation of $25,000 for the improvement of Penobscot River, it was provided that $10,000 of it should be "expended at and near Bucksport Narrows," 18 miles below Bangor. With a view to ascertaining the nature and extent of the desired improvement at this place, I had an accurate survey made by Assistant Engineer Mr. A. C. Both, showing that a shoal, known as the Middle Ground, existed in front of the wharves of Bucksport, on which there was in some places but 4 feet of water at mean low-water. This shoal was a serious obstruction to navigation, and, with the sanction of

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the Department, it was decided that the appropriation ($10,000) be applied to the removal of the shoal to a depth of 12 feet at mean low-water (or 22.3 feet at mean high-water) from its upper extremity downward to as great an extent as could be done under the appropriation. Proposals were accordingly invited for this work until the 12th of July, 1875, when the contract therefor was awarded to Messrs. Curtis, Fobes & Co., of Portland, Me., the lowest of two bidders, for 50,000 cubic yards, more or less, of dredging, at 12½ cents per cubic yard, as measured in the scows. This contract (dated July 16, 1875) was completed on the 21st of October, 1875, resulting in 61,910 cubic yards of dredging.

All the surveys and operations pertaining to the improvement of this river have been carried on during the past four years under the immediate superintendence of Assistant Engineer Mr. A. C. Both.

Abstracts of proposals received and contracts made during the past year are hereto appended.

Money statement.

Amount available July 1, 1875	$68,885 18
Amount expended during fiscal year ending June 30, 1876	23,840 90
Amount available July 1, 1876, including $1,022 due on contracts	45,044 28
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	6,000 00

Abstract of proposals received July 12, 1875, for dredging at Bucksport Narrows, Penobscot River, Maine.

Number for reference.	Bidders.	Nature of work.	Price per cubic yard.	Remarks.
1	Curtis, Fobes & Co., Portland, Me.	Dredging	$0 12½	As measured in the scows.
2	Charles H. Lewis, Boston, Mass	do	39.9	Do.

Abstract of contract made during the fiscal year ending June 30, 1876, for the improvement of Penobscot River, Maine.

Date of contract.	Contractor.	Nature and location of work.	Price per cubic yard.	Remarks.
1875. July 16	Curtis, Fobes & Co., Portland, Me.	Dredging 50,000 cubic yards, more or less, at Bucksport Narrows.	$0 12½	As measured in the scows.

A 4.

IMPROVEMENT OF CAMDEN HARBOR, MAINE.

The following appropriations have been made for the improvement of this harbor, viz:

By act of Congress approved March 3, 1873	$10,000 00
By act of Congress approved June 23, 1874	10,000 00
By act of Congress approved March 3, 1875	10,000 00
Total	30,000 00

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These appropriations were based on an estimate submitted by me to the Department, December 17, 1872, in my report on the survey of Camden Harbor, made with a view to its improvement, as called for by act of Congress approved June 10, 1872, "making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes." This estimate consisted of the following items, viz:

	Cubic yards.
1. Regulating the entrance by dredging between Portland steamer and Sanford's steamer wharves, and dredging a channel 100 feet wide, 1,000 feet long, and 7 feet deep at mean low-water from said entrance to the head of the wharves on the easterly side of the harbor; amount of excavation...	46,500
2. For dredging a channel 80 feet wide, 1,400 feet long, and 3 feet deep at mean low-water on westerly side of the harbor to the head of the wharves, and connecting with the above-mentioned improvements; amount of excavation	13,500
Addition of 25 per cent. for loosening of material by dredging	15,000
Total	75,000

The estimated cost of which, at 40 cents per cubic yard, is	$30,000 00
Adding for engineering expenses and other contingencies	3,000 00
Total	33,000 00

Under the appropriation of March 3, 1873, a contract was made May, 14, 1873, by which 22,753 cubic yards of dredging was done in 1873, at 40 cents per cubic yard. By this work a good channel was opened to a depth from 7 to 9 feet at mean low-water, and for a width of 50 to 100 feet, extending from deep water (9 feet at mean low-water) near the Portland steamer wharf up to the head of the wharves on the eastern side of the harbor; altogether, a distance of about 2,000 feet.

Under the appropriation of June 23, 1874, a contract was made August 15, 1874, with Mr. Augustus R. Wright, of Geneva, N. Y., for 30,000 cubic yards of dredging, at 28 cents per cubic yard, as measured in the scows; and under the appropriation of March 3, 1875, another contract was made May 13, 1875, with Mr. A. R. Wright, for 40,000 cubic yards, more or less, of dredging, at 18 cents per cubic yard, as measured in the scows. Mr. Wright's contract of August 15, 1874, for 30,000 cubic yards was commenced June 23, 1875, and was completed July 26, 1875; and that of May 13, 1875, was commenced July 26, 1875, and was completed September 30, 1875, by which 52,199 cubic yards of dredging was done, making a total of 82,199 cubic yards under his two contracts, and a total under all three contracts of 104,952 cubic yards.

Owing to the cost of the work being much lower than was estimated for, whereby about 30,000 cubic yards more of dredging was done than was originally contemplated, the project for the improvement of this harbor was, with the sanction of the Department, modified so as to give a depth of 7 feet (instead of 3 feet) at mean low-water (or $16\frac{6}{10}$ feet at mean high-water) to the channel on the western side of the harbor, being the same as on the eastern side, each channel having a width of not less than 80 feet in any place.

All the work contemplated for the improvement of this harbor has been completed, and no further appropriation is required therefor.

Money statement.

Amount available July 1, 1875	$19,393 30
Amount expended during fiscal year ending June 30, 1876	19,393 30

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A 5.

IMPROVEMENT OF KENNEBEC RIVER, MAINE.

The following appropriations have been made by Congress for the improvement of this river, viz:

By act approved June 23, 1866	$20,000
By act approved March 2, 1867	30,000
Allotted under act approved April 10, 1869	15,000
By act approved July 11, 1870	15,000
By act approved March 3, 1871	15,000
By act approved June 10, 1872	8,000
By act approved March 3, 1873	12,000
By act approved June 23, 1874	12,000
By act approved March 3, 1875	15,000
Total	142,000

All the improvements projected for this river above Richmond, Me., were completed prior to June 30, 1874, as described in my annual report for the fiscal year ending that date, whereby a safe and unobstructed channel, not less than 100 feet in width and 10 feet in depth at mean low-water, or 15½ feet at mean high-water, in its low summer stages, had been completed from Richmond up to Gardiner, a distance of 11 miles; and thence to Augusta, a distance of 7 miles; a channel 100 feet in width, and not less than 6½ feet in depth at low-water, or 11 feet at high-water, in its lowest summer stages. This improvement included the removal of a very dangerous ledge, known as Nehumkeg Rock, (between Richmond and Gardiner,) to a depth of 12 feet below mean low water, and below Richmond, Half Tide Rock and three other sunken ledges have been removed from the channel at "the Narrows," whereby all the work contemplated for the improvement of this river has been completed, with the exception of the removal of Dry Rock, in "the Narrows."

In my project of March 24, 1875, which was approved by the Department, it was recommended that the appropriation of $15,000 made by act of March 3, 1875, together with the balances then available of former appropriations, altogether amounting to $29,214.28, should be applied to the removal of Dry Rock, the work to be done by contract. On the 6th of May, 1875, a contract was made with Mr. Isaac Hamilton, of Portland, Me., the lowest of five bidders, for removing Dry Rock, (1,775 cubic yards,) at $15 per cubic yard, as measured in its bed, so as to have over it a depth of 12 feet at mean low-water. Work was commenced under this contract on the 2d of June, 1875, and was continued up to the 20th of November last, when it was suspended on account of freshets and ice.

The progress made during the season was far from satisfactory, there having been but about 325 cubic yards of the rock removed. Operations were resumed on the 2d of June, 1876, being the earliest date practicable on account of the continued freshet in the river, and it is believed that, with advantage of improved machinery and the experience of last year, much more satisfactory progress will be made this season, resulting, probably, in the entire removal of the rock.

The funds now available are sufficient for completing this, the only remaining work to be done, so that no further appropriation will be needed.

Money statement.

Amount available July 1, 1875	$28,548 38
Amount expended during fiscal year ending June 30, 1876	733 05
Amount available July 1, 1876	27,815 33

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A 6.

IMPROVEMENT OF PORTLAND HARBOR, MAINE.

The following appropriations have been made by Congress for the improvement of this harbor, viz:

By act approved June 23, 1866	$105,111 05
By act approved July 11, 1870	10,000 00
By act approved March 3, 1871	40,000 00
By act approved June 10, 1872	45,000 00
By act approved March 3, 1873	50,000 00
By act approved June 23, 1874	20,000 00
By act approved March 3, 1875	20,000 00
Total	290,111 05

Amount expended up to July 1, 1875	$243,036 67	
Amount expended during the fiscal year ending June 30, 1876	2,505 40	
		245,542 07
Amount available July 1, 1876		44,568 98

Up to the 1st of July, 1875, the following work had been done for the improvement of this harbor, viz:

1. The breakwater extended for a length of 217 feet and a granite pier built at its outer extremity, and 950 linear feet of capping placed upon the breakwater in completion of same.

2. A channel dredged through the Middle Ground Bar to a width of 500 feet and to a depth of 21 to 22 feet at mean low-water, or 31 feet at ordinary high-water.

3. A channel dredged through the "spit" in front of the Grand Trunk Railway wharves, to a width of 100 feet at its inner end and 200 feet at its outer end, and to a depth of 20 feet at mean low-water.

4. A channel dredged in Back Bay from Tukey's Bridge up to the "stone shed wharves," to a width of 100 feet and a depth of 8 feet at mean low-water.

5. A sunken wreck removed from the main ship-channel between Forts Preble and Scammel.

6. The foundation of the oldest portion of the breakwater repaired throughout its whole extent where necessary.

7. All the projected dredging in front of the Grand Trunk Railway wharves has been completed to a depth of 20 feet at mean low-water, and all that in front of the harbor commissioners' line from Atlantic wharf up to Merrill's wharf to a depth of 16 feet at mean low-water.

The following work has been done in this harbor during the fiscal year ending June 30, 1876, viz:

1. Deepening the dock at custom-house wharf by 2,932 cubic yards of dredging, the same having been authorized by the Department, upon the request of the honorable Secretary of the Treasury.

2. Triangulation and surveys made of portions of the harbor.

All the work that has been projected for the improvement of this harbor has been completed, with the exception of the dredging outside the harbor commissioners' line above Merrill's wharf, for the completion of which the funds now available are sufficient, so that no further appropriation is needed for this harbor.

In regard to the dredging that remains to be done above Merrill's wharf outside the harbor commissioners' line, it has been decided to defer the work until Brown's, Boston and Maine Railroad, (formerly Smith's,) Hobson's, and the other wharves which project beyond the

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harbor commissioners' line shall have been cut off up to that line, for the reason that this work of improving the harbor in front of that line was initiated and recommended, and all the appropriations made therefor in 1873, 1874, and 1875, aggregating $90,000, have been asked for with the understanding that those projecting wharves should first be removed, in order to make the contemplated improvement effective and lasting, for so long as those wharves are permitted to project outside the harbor lines, so long will the eddies and shoals continue to exist above and below those wharves. This has already been clearly proved by a recent survey of the space dredged over last season in front of and above Central wharf, where new deposits in large quantity have been found.

The above described works are situated in Portland Harbor, in the collection-district of Portland and Falmouth.

The amount of revenue collected at this port during the fiscal year ending June 30, 1876, as furnished by the United States collector of customs, was	$403,936 58
Total value of imports for same period	$1,200,344
Number of vessels entered, 1,198, equal to	888,860 tons.
Number of crew employed	20,104

Money statement.

Amount available July 1, 1875	$47,074 38
Amount expended during fiscal year ending June 30, 1876	2,505 40
Amount available July 1, 1876	44,568 98

A 7.

IMPROVEMENT OF RICHMOND'S ISLAND, MAINE.

This work consists in making a harbor of refuge by means of a stone breakwater connecting the island with the main land; the length of the breakwater to be about 2,000 feet, with an average thickness of 30 feet and a height of 13 feet above mean low-water.

In my report to the Department, dated May 10, 1867, the following estimate of the cost of this breakwater was submitted:

68,000 tons of rubble-stone, at $1.25	$85,000 00
Adding 10 per cent. for contingencies	8,500 00
Total	93,500 00

A capping for this work was not then estimated for, on account of the great increase of cost; but, as then stated, should it hereafter be found necessary to resist the action of the sea, which is not probable, it can then be added.

The following appropriations have been made by Congress for this work, viz:

By act approved June 10, 1872	$20,000 00
By act approved March 3, 1873	60,000 00
By act approved March 3, 1875	15,000 00
Total	95,000 00

The following contracts have been made for furnishing stone for this work, viz:

1. With Edward Moore, of Portland, Me., August 22, 1872, for 15,000 tons, more or less, at $1.24 per ton of 2,240 pounds, under the appropriation of June 10, 1872, by which he furnished, up to August 30, 1873, $15{,}012\frac{600}{2240}$ tons in completion of his contract;

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2. With James M. Andrews, of Biddeford, Me., May 26, 1873, for 25,000 tons, more or less, of large quarry grout, at $1.75 per ton of 2,240 pounds, under the appropriation of March 3, 1873, by which he furnished, up to June 26, 1874, 25,989$\frac{1640}{2240}$ tons in completion of his contract;

3. With Isaac Hamilton, of Portland, Me., May 26, 1873, for 6,000 tons, more or less, of small bowlders, at $1.59 per ton of 2,240 pounds, under the appropriation of March 3, 1873, by which he furnished, up to August 31, 1874, 6,970$\frac{1200}{2240}$ tons in completion of his contract;

4. With David N. Hill and Solomon F. Hamilton, of Cumberland, Me., May 6, 1875, for 9,000 tons, more or less, of large quarry grout, at $1.37 per ton of 2,240 pounds, to be delivered on or before the 30th of September, 1875; and

5. With Isaac Hamilton, of Portland, Me., May 6, 1875, for 1,500 tons, more or less, of small bowlders, at $1.10 per ton of 2,240 pounds, to be delivered on or before the 30th of September, 1875.

Of the above contracts, that made May 6, 1875, with David N. Hill and Solomon F. Hamilton, (which was about half finished at the beginning of this fiscal year,) was entirely completed on the 28th of August, 1875, 8,695$\frac{1200}{2240}$ tons of stone having been furnished by them; and that made May 6, 1875, with Isaac Hamilton, was completed on the 21st of August, 1875, 1,473$\frac{480}{2240}$ tons of stone having been furnished by him.

From the foregoing it is seen that 58,143$\frac{240}{2240}$ tons of stone have been furnished and placed upon the breakwater, and that 10,000 tons more will be required to finish the work as originally projected, the estimated cost of which 10,000 tons, including contingences, as stated in my last annual report and therein asked for, is $15,000, thereby making the total cost of the work completed $110,000, which is $16,500 in excess of the original estimate. This excess is owing to the greater cost of the stone than was originally estimated, the quantity being the same.

Money statement.

Amount available July 1, 1875	$7,269 83
Amount expended during fiscal year ending June 30, 1876	7,269 83
Amount (estimated) required for completion of existing project	15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	15,000 00

A 8.

IMPROVEMENT OF KENNEBUNK RIVER, MAINE.

By an act of Congress, approved July 11, 1870, the sum of $5,000 was appropriated for the improvement of this river. No report or estimate had previously been made upon which this appropriation was based. But an investigation showed, as stated in my report to the Department dated August 16, 1870, that about 17 years previously, stone piers had been built on each side of the river at its mouth, for the purpose of improving the course and depth of the channel at the entrance into the river; that on the outer end of the eastern pier a wooden light-house had been built and was afterwards destroyed by the storms; and that a wharf had been built on the left (eastern) shore of the river about one-eighth of a mile above its mouth for the security of vessels while awaiting tides and storms. It was also ascertained that the wings or returns connecting these stone piers with the banks, which

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were built of timber, had been destroyed by storms and that the Government wharf was also much in want of repairs; but that the most necessary work to be done under the appropriation was the rebuilding with stone the eastern wing, so as to prevent the flow of sand from the outside into the channel of the river. This wing was completed December 15, 1870, for a length of 168 feet, under a contract made October 12, 1870, with Messrs. Albert Blaisdell and Joseph S. Bailey, both (then) of Portland, Me., for the sum of $21.35 per linear foot. Under the same appropriation some repairs were made on the main eastern pier as well as upon the Government wharf.

With a view to repairing the western stone pier and rebuilding with stone the wing connecting it with the shore, the estimated cost of which was $5,000, an additional appropriation was made therefor by act of Congress approved March 3, 1871. Under this appropriation the western wing was completed in August, 1871, for a length of 166⅔ feet, under a contract made May 5, 1871, with Mr. Charles H. Bragdon, of Biddeford, Me., for $18.62 per linear foot. Under the same appropriation, the much needed repairs were made, with hired labor, upon both stone piers, and upon the Government wharf above, which were entirely completed in August, 1872, whereby the appropriations for this river were exhausted.

By an act of Congress approved June 23, 1874, a survey of this river was called for, with a view to its further improvement. A report on this survey, dated December 2, 1874, accompanied my annual report for the year ending June 30, 1875, in which an estimate of $5,000 was submitted for the improvement of this river from its mouth up to the drawbridge at Kennebunkport, a distance of 1⅛ miles, for items as follows, viz:

1. Removal of 4,200 cubic yards of mud and clay at Mitchell's Point, at 75 cents per cubic yard	$3,150 00
2. Removal of 1,300 cubic yards of sand, sods, and logs, at the "Wading Place," at $1 per cubic yard	1,300 00
Contingencies, say	550 00
Total	5,000 00

Money statement.

Amount appropriated by act approved August 14, 1876	5,000 00

A 9.

IMPROVEMENT OF COCHECO RIVER, NEW HAMPSHIRE.

This river in its lowest summer stage is navigable, with 6 feet of water at mean low water, or 13½ feet at ordinary high water, from the harbor of Portsmouth, N. H., up to the Lower Narrows, which place is about 10 miles above Portsmouth, and 1½ miles below the bridge at the head of navigation in Dover, N. H. At the Lower Narrows and above its navigation has hitherto been much obstructed by ledges, bowlders, and shoals, having only from 6 inches to 2 feet of water over them at mean low water. The average rise and fall of the tide is 6.8 feet at the Lower Narrows, and less above.

The project for the improvement of this river consists in making a channel, not less than 40 feet in width and 4 feet in depth at mean low water, from the foot of the Lower Narrows up to the Packet Landing.

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By act of Congress approved July 11, 1870, an examination or survey of this river was called for, with a view to its improvement. In my report, on an examination, to the Department, December 12, 1870, which accompanies my annual report for 1871, the following estimates were submitted, viz:

1. Excavating and removing 1,000 cubic yards ledge at the Lower Narrows, at $15 per cubic yard	$15,000
2. Excavating 1,500 cubic yards loose rocks, gravel, &c., at Trickey's Shoal, at $1 per cubic yard	1,500
3. Excavating 1,500 cubic yards loose rocks, &c., at Clement's Point Shoal, at $1 per cubic yard	1,500
4. Excavating 1,500 cubic yards ledge at the "Gulf" (Upper Narrows) and above, at $15 per cubic yard	22,500
5. Excavating 1,000 cubic yards gravel above the "Gulf," at 50 cents per cubic yard	500
Contingencies	4,000
Total	45,000

This estimate provided for improving the river up as far as Collins's wharf only.

The following appropriations have been made by Congress for the improvement of this river, viz:

By act approved March 3, 1871	$10,000
By act approved June 10, 1872	10,000
By act approved March 3, 1873	10,000
By act approved June 23, 1874	10,000
By act approved March 3, 1875	25,000
Total	65,000

Under the appropriation of March 3, 1871, a contract was made May 25, 1871, with Messrs. Morris & Cumings, of New York City, for the excavation of about 400 cubic yards of ledge at the Lower Narrows, for the sum of $7,000, which they completed in October, 1871. Under the same appropriation numerous sunken rocks, lying in the channel between the Lower and Upper Narrows, (including Watson's Rocks,) as well as some rocks below the Lower Narrows, were removed.

Under the appropriations of June 10, 1872, and March 3, 1873, contracts were made October 26, 1872, and May 1, 1873, respectively, with Mr. Edward Moore, of Portland, Me., for the excavation and removal from the Upper Narrows of altogether 772 cubic yards of ledge, at $26.50 per cubic yard, measured *in situ*, so as to have a channel 40 feet in width and 4 feet in depth at mean low water, by which that channel was opened on the 31st of October, 1873, for a length of about 300 feet. Under the appropriation of June 23, 1874, another contract was made July 31, 1874, with Mr. Moore, for *completing* the channel through the Upper Narrows for a length of about 130 feet, by which he excavated 483 cubic yards, at $20 per cubic yard, measured *in situ*, in completion of his contract on the 17th of November, 1874.

Careful surveys of this river, made since 1870, from its mouth at Dover Point up to the wharves of Dover, have shown the necessity of extending the improvements up as far as the Packet Landing, which extension, together with the fact that the ledge-excavation already done has cost much more than the original estimate, as shown above, has necessitated an increase of the estimate first submitted, as follows, viz:

1. Original estimate of December 12, 1870, as above	$45,000 00
2. Additional amount that it *has cost* by contract for excavating ledge at "Gulf"	7,618 00
3. Excavating channel through ledge above "Gulf" and in front of Collins's wharf, (completed)	15,000 00

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4. 4,874 cubic yards dredging (already done) above Collins's wharf, at 40 cents per cubic yard	$1,949 60
5. 10,000 cubic yards of projected dredging above "Gulf," at $1 per cubic yard	10,000 00
6. Removal of sunken rock at Dover Point, now projected, say	2,500 00
Add for contingencies, say	2,932 40
Total	85,000 00
As above stated, there had been appropriated up to the 1st of July, 1875, the sum of	$65,000 00
Of which there had then been expended, (as above)	40,134 02
Leaving available July 1, 1875	24,865 98

Under the balance of the appropriation of March 3, 1875, the following contracts were made, viz:

1. With Mr. James Andrews, of Biddeford, Me., May 8, 1875, for opening a channel through the ledge above the Upper Narrows and in front of Collins's wharf to a width of 40 feet and a depth of 4 feet at mean low water, requiring the excavation of 1,108 cubic yards of solid ledge, rotten ledge, bowlders, clay, &c., for the sum of $15,000.

Work was commenced under this contract on the 1st of June, 1875, and was completed in a very satisfactory manner on the 30th of September, 1875.

2. With Mr. Augustus R. Wright, of Geneva, N. Y., May 13, 1875, for 12,000 cubic yards, more or less, of dredging, which contract was completed by him November 24, 1875, resulting in 4,874 cubic yards of dredging above Collins's wharf, at 40 cents per cubic yard, and 2,234 cubic yards below Collins's wharf, at 70 cents per cubic yard, as measured in the scows.

After the completion of these two contracts of May 8 and 13, 1875, there remained of the appropriation of March 3, 1875, an available balance of $5,067.53, which, under the authority received in Department letter of April 11, 1876, is being applied to the removal of scattered ledges and bowlders above and below as well as at the Lower Narrows; those being the most serious obstacles now remaining in the river.

In place of the project heretofore under consideration for extending the channel from Packet Landing up through the ledge to the basin at the factories and bridge for a width of 30 feet and a depth of 2 feet at mean low water, it is recommended, in view of its great cost, to substitute therefor the plan of making a basin at the Packet Landing below the ledge, having an area of 12,000 square yards, with a depth of 4 feet at mean low-water or about 11 feet at high water, the estimated cost of which as above is $10,000.

This plan will afford all the facilities that the commerce of this place may require for the present at a great saving in cost of the work.

Money statement.

Amount available July 1, 1875	$24,865 98
Amount expended during fiscal year ending June 30, 1876	21,984 42
Amount available July 1, 1876	2,881 56
Amount appropriated by act approved August 14, 1876	14,000 00
Amount (estimated) required for completion of existing project	6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	6,000 00

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A 10.

IMPROVEMENT OF MERRIMAC RIVER, INCLUDING THE HARBOR OF NEWBURYPORT, MASSACHUSETTS.

The original project for the improvement of this river consisted in the removal of certain obstructions to navigation, near its mouth, in the harbor of the city of Newburyport, Mass., and others at the Upper and Lower Falls, about 4 miles above Haverhill.

The estimated cost of these improvements, as submitted by the engineer then in charge of the work, in his report of August 16, 1869, which appears in the annual report of 1870, was as follows, viz:

Removing obstructions, consisting of bowlders, sand, &c., at the Upper and Lower Falls, above Haverhill, 4,040 cubic yards	$50,500 00
Adding 10 per cent. for contingencies	5,050 00
Removal of South Gangeway Rock	8,337 50
Removal of wreck of coal-vessel sunk near mouth of the river	5,000 00
Removal of Boilers, (rocks,) near city wharves	5,000 00
Add for contingencies on last two items, 10 per cent	1,000 00
Total	$74,887 50

Since the above estimate was submitted to the Department, much additional work has been projected and finished, estimates for which have been submitted in subsequent annual reports, which have materially added to the original estimate, as follows, viz.:

1. It has been found that in the Upper and Lower Falls, above Haverhill, instead of bowlders and sand estimated for, about 12,800 cubic yards of solid ledge, bowlders, clay, and gravel have been excavated to obtain the projected width of 60 feet and depth of 4 feet, at an increased cost of-	$34,612 50
That in Hazeltine Rapids, 620 cubic yards of bowlders, clay, gravel, &c, (not originally estimated for,) had to be removed, the cost of which has been, including contingencies	3,500 00
2. The cost of completing the removal (commenced in 1870,) of North Gangeway Rock, in Newburyport Harbor, (being for 700 cubic yards, at $20 per cubic yard,) including contingencies not originally estimated for-	15,000 00
4. In pursuance of the act of Congress approved June 10, 1872, "making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," a survey was made of Merrimac River, "from Haverhill to Newburyport, including Duck Hole and Currier Shoal," with a view to the improvement of its navigation, the estimated cost of which, as shown in annual report for 1873, but not before then estimated for, is	19,000 00
Total	72,112 50
Making the total estimate for the work already done and that now projected	$147,000 00

The following appropriations have been made by Congress for the improvement of this river, based upon the foregoing estimates, viz:

By act of July 11, 1870, for improvement of Merrimac River, Massachusetts	$25,000 00
By act of March 3, 1871, for improvement of Merrimac River above Haverhill, Mass	25,000 00
By act of June 10, 1872, for improvement of Merrimac River above Haverhill, Mass	25,000 00
By act of March 3, 1873, for improvement of Merrimac River, Massachusetts	25,000 00
By act of June 23, 1874, for continuing the improvement of Merrimac River, Massachusetts	10,000 00
By act of March 3, 1875, for improvement of Merrimac River, Massachusetts	12,000 90
Total	$122,000 00
The additional amount required, therefore, for completing the works now projected is	25,000 00
The amount that had been expended up to the 1st of July, 1875, was	108,836 45
Leaving then available the sum of	13,163 55

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On referring to my annual report for the fiscal year ending June 30, 1875, it will be seen that all the projected work at the falls above Haverhill had then been completed, and that South Gangeway Rock and the wrecked vessel in Newburyport harbor had been removed; also that the shoals near Rocks bridge had been improved by dredging, and that numerous sunken bowlders, including Little Currier Rock, which obstructed the channel above and below Rocks bridge, (6½ miles below Haverhill,) as well as those inside the draw of the bridge, had been removed.

In July, 1875, a large number of dangerous sunken rocks were also removed from Currier Shoal, and still more from the channel below Rocks bridge, including Petty Rock, greatly improving this the most dangerous part of the river below Haverhill.

The project adopted for the improvement of this river consists in obtaining a depth of 12 feet of water, at ordinary high-water, from its mouth up to Haverhill.

Under the appropriation of March 3, 1875, a contract has been made with Messrs. Curtis, Fobes & Co., of Portland, Me., the lowest bidders, for 6,500 cubic yards, more or less, of dredging at Currier Shoal, (about four miles below Haverhill,) at 35 cents per cubic yard, as measured in the scows. Operations were commenced under their contract on the 19th June, 1876, and it is probable that they will be completed not later than the end of July.

The balance of the funds that will be available after completing the improvement at Currier Shoal is to be applied to other projected work remaining to be done between Haverhill and Newburyport.

Money statement.

Amount available July 1, 1875	$13,163 55
Amount expended during fiscal year ending June 30, 1876	2,703 01
Amount available July 1, 1876	10,460 54
Amount (estimated) required for completion of existing project	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	25,000 00

A 11.

IMPROVEMENT OF GLOUCESTER HARBOR, MASSACHUSETTS.

By an act of Congress approved June 10, 1872, the sum of $10,000 was appropriated for the removal of sunken rocks in this harbor, and with it they have all been removed to the extent contemplated, being as follows, viz:

1. Clam Rock, removed from a depth of 1 foot to 9⅓ feet below the plane of mean low-water, the level of the surrounding bottom;

2. Pinnacle Rocks, removed from 8½ feet above down to the level of the surrounding bottom, which has a depth of 16½ feet below the plane of mean low-water;

3. Rocks off J. Friend's wharf, removed down to the level of the surrounding bottom;

4. Rock off Pew's wharf was entirely removed to a depth of 5 feet below mean low-water; and

5. The largest bowlders were removed from the rocky shoal known as "Babson's Ledge."

Work has been suspended since July 1, 1873.

Money statement.

Amount available July 1, 1875	$686 84
Amount expended during fiscal year ending June 30, 1876	579 10
Amount available July 1, 1876	107 74

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A 12.

IMPROVEMENT OF SALEM HARBOR, MASSACHUSETTS.

The act of Congress approved June 10, 1872, "making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," provided for a survey of this harbor, with a view to its improvement. A survey of it, made in August and September, 1872, by Mr. Sophus Haagensen, assistant engineer, showed that the following works were necessary, viz:

1. The excavation by dredging of a channel 1,730 feet long, 300 feet wide, and 8 feet deep at mean low-water, (giving 17.3 feet at mean high-water,) from deep water to the entrance of South River, the estimated cost of which was as follows, viz:

(*a*) Excavating 36,000 cubic yards of mud, at 50 cents	$18,000 00
(*b*) Excavating 12,000 cubic yards of hard clay, at 90 cents	10,080 00
Adding for contingencies, say	3,920 00
Total	32,000 00
2. For constructing a sea-wall and breakwater for the protection and preservation of Long Point, as per estimate given in annual report of 1873	23,000 00
Total	55,000 00

Upon the above estimates appropriations have been made by Congress as follows, viz:

By act approved March 3, 1873	$15,000 00
By act approved June 23, 1874	10,000 00
Total	25,000 00

Under the appropriation of March 3, 1873, a contract was made with Mr. Augustus R. Wright, of Geneva, N. Y., for dredging, at 44 cents per cubic yard, as measured in the scows, by which the channel was opened to the projected length and depth for a width of 160 feet.

Under the appropriation of June 23, 1874, a contract was made, September 5, 1874, with Messrs. Curtis, Fobes & Co., of Portland, Me., the lowest of four bidders, for completing all the projected dredging at this place, at the following prices, viz:

(1) Stiff clay intermixed with bowlders at 35 cents per cubic yard, as measured in the scows; and (2) soft mud at 20 cents per cubic yard, as measured in the scows.

Work was commenced under this contract December 9, 1874, and was completed April 20, 1875, resulting in the dredging of 1,945 cubic yards of clay and bowlders and 41,558 cubic yards of soft mud, altogether 43,503 cubic yards, whereby the channel was completed to a width of 300 feet, as originally projected.

Money statement.

Amount (estimated) required for completion of existing project	$23,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	23,000 00

A 13.

IMPROVEMENT OF BOSTON HARBOR, MASSACHUSETTS.

The works projected and commenced prior to 1866 for the improvement of Boston Harbor consisted of the sea-walls on Deer Island, Lovell's Island, and Great Brewster Island. Those on Deer Island were

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commenced in 1827, and were completed, as partially rebuilt, in 1869; those on Lovell's Island were commenced in 1843 and completed in 1869; and that on Great Brewster Island was commenced in 1849 and completed in 1869.

On referring to the annual reports from 1866 to 1870, it appears that up to 1870 there had been expended upon the Great Brewster sea-wall the sum of $277,082.55, and for those upon Deer and Lovell's Islands the sum of $133,420.24, (from 1866 to 1870,) in addition to the appropriations made prior to 1866. These sea-walls, which had been under the charge of Colonel H. W. Benham, Corps of Engineers, since 1865, were transferred to the charge of Lieut. Col. George Thom, Corps of Engineers, in April, 1873.

In 1866 new works for the further improvement of this harbor were planned by the board of harbor commissioners, organized by the legislature of Massachusetts, and estimates therefor were submitted by them as follows, viz:

For the improvement of the channel across the Upper Middle Bar, by dredging a channel 23 feet deep at mean low-water, and 1,000 feet wide, at a total estimated cost of	$157,085 00
For the improvement of the channel at the Narrows by dredging off the southwest point of Lovell's Island and the extremity of Great Brewster Spit, so as to widen the channel to 685 feet at 23 feet depth of water, at a total estimated cost of	188,805 00
For the improvement of the channel at the Narrows, by the removal by blasting of Tower Rock and Corwin Rock, at an estimated cost of	20,000 00
For the preservation of the north head of Long Island, by the construction of a sea-wall, at an estimated cost of	150,000 00
For the preservation of the north end of Gallop's Island, by the construction of a sea-wall, at an estimated cost of	103,585 63
For the preservation of Point Allerton, by the construction of a sea-wall, at an estimated cost of	70,991 87
Total	690,467 50

An appropriation based upon these estimates having been made by Congress, in March, 1867, the late Lieut. Col. J. G. Foster, Corps of Engineers, was assigned to the charge of those works in May, 1867, and they continued under his charge until May, 1871, when they were transferred to Lieut. Col. Thom, Corps of Engineers.

For the several works, projected as above in 1866 and since, the following appropriations have been made by Congress to date, viz:

By act approved March 2, 1867, for preservation and improvement of Boston Harbor, Massachusetts		$375,000 00
Allotted under act of July 25, 1868		43,000 00
Allotted under act of April 10, 1869		82,170 00
By act approved July 11, 1870, for preservation and improvement of Boston Harbor, Massachusetts		100,000 00
By act approved March 3, 1871, for improvement of Boston Harbor, Massachusetts		100,000 00
By act approved June 10, 1872, for the improvement of Boston Harbor, Massachusetts		100,000 00
By act approved March 3, 1873, for the improvement of Boston Harbor, Massachusetts, including Deer and Lovell's Islands		150,000 00
By act approved June 23, 1874, for continuing the improvement of the harbor at Boston, Mass		100,000 00
By act approved March 3, 1875, for the improvement of Boston Harbor, Massachusetts	$100,000 00	
Providing that $10,000 of said amount may be expended for the improvement of Hingham Harbor	10,000 00	
		90,000 00
Total		1,140,170 00

The following is a brief history of each of the works, completed and uncompleted, that have hitherto been projected for the improvement of this harbor, viz:

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1.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF POINT ALLERTON.

Work was commenced upon this sea-wall in September, 1870, and was completed in May, 1874. It was built for the most part under four separate contracts with Mr. James M. Andrews, of Biddeford, Me., made respectively May 24, 1870, July 26, 1871, August 24, 1872, and May 8, 1873. The total length of this sea-wall completed is 1,202 feet.

In addition to this sea-wall there have been built since July, 1873, for the protection of its concrete foundation where most exposed to injury by storms and currents, 1,005 linear feet of granite apron and eight jetties, in which have been placed 1,776 tons of grout. This apron has an average width of 10 feet and a height of 2 to 3 feet. It extends all along the fourth, fifth, sixth, seventh, and eighth faces, (counting from the east,) and for about 55 feet along the first face as well as along the western wing-wall in order to protect its junction with the shore crest. The several jetties have a length of 25 to 30 feet, a width of about 6 to 8 feet, and a height of 2 to 3 feet; and they are placed one at each of the fourth, fifth, sixth, seventh, and eighth angles, one each at the middle of the first and seventh faces, and at the easterly wing-wall.

A recent inspection of this sea-wall shows that it is in excellent condition in every respect, and that the riprap apron-work has fully answered the purpose for which it was intended.

2.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF GREAT BREWSTER ISLAND.

This wall, 2,840 feet in length, was built for the protection of the north and south heads of the island. It was commenced in the year 1849, and was continued through the year 1850, when work upon it was suspended. Since then it has been continued from time to time, as appropriations have been made for it, until its completion in 1869. This wall is generally in good condition. In several places the mortar has been washed out of the joints to an extent necessitating repairs.

3.—SEA-WALLS FOR THE PROTECTION AND PRESERVATION OF LOVELL'S ISLAND.

Two sea-walls have been built by the United States Government on this island, one in 1843, for the protection of its north head for a length of 750 feet, and the other in 1868–'69, for the protection of its southeast bluff for a length of about 800 feet.

For the protection of the shore-line south of the north head wall an apron-work of large rubble-stone was built in 1873, for a length of 620 were used; and for the protection of the shore-line next to the southern feet, with five jetties projecting from it, in which 1,095 tons of stone end of the southeastern sea-wall, a rubble-stone apron 110 feet in length was also built, in 1873, in which 139 tons of stone were used. A recent inspection of these aprons shows that they have fully answered the purpose for which they were intended.

The wall on the southeast bluff has been much damaged by storms during the past year, and especially by the gales of March and April, 1876. Over 300 linear feet of the coping-course has been removed, and the cobble-stone paving back of the coping has been washed out for a length of about 400 feet. Injury has also been done to the stone jetties, and the joints in several places have been opened. To prevent a recur-

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rence of such damage it is recommended that greater relief be given to the wall (now but 8 feet above its concrete foundation) by adding two more facing courses, each of 2 feet, and by substituting for the cobble-stone pavement in rear of the coping, granite flagging, resting on a shingle and gravel bed. The cost of this change, including the repairs now necessary, is estimated at $15,000.

4.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF GALLOP'S ISLAND.

This sea-wall is 1,785½ feet in length. Work upon it was commenced in 1868, under a contract with Mr. James Andrews, of Biddeford, Me., and was carried on under that contract until the end of April, 1871, after which it was continued with hired labor until its completion in the latter part of September, 1871.

The violent storms and currents to which this sea-wall is exposed had laid bare its concrete foundation to such a degree as to render necessary for its protection and preservation a rubble-stone apron for nearly its whole extent, with the addition of jetties in the most exposed places. This apron-work was commenced in August, 1873, and was completed in May, 1874. It extends along the sea-wall for a length of 1,655 feet, being on its most exposed faces 10 feet in width. Nine jetties have been built at and near the angles of the wall, four of which are of split granite, bedded in part in concrete laid in trenches and surrounded with a concrete apron, each jetty being 18 feet in length and 5 feet in width. The quantity of stone used in this apron and the jetties was about 1,450 tons. A recent inspection of this work shows that it is in good condition, and that the riprap apron-work and jetties have fully answered the purpose intended. Some repairs, however, are necessary for the apron-work, which has been somewhat disturbed in one or two places by recent gales.

5.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF THE NORTH HEAD OF LONG ISLAND.

Work was commenced upon this sea-wall in August, 1870, and was completed in July, 1874. It has been built, for the most part, under four separate contracts with Mr. James Andrews, of Biddeford, Me., made respectively May 24, 1870, July 26, 1871, August 23, 1872, and May 8, 1873. The length of this sea-wall is 2,081¾ feet.

In addition to the sea-wall there has been built for the protection and preservation of its concrete foundation, where most exposed to injury by storms and currents, a rubble-stone apron for a length of 975 feet in front of the wall, together with 10 stone jetties. This apron averages from 8 to 10 feet in width, and from 2 to 3 feet in height. The jetties are triangular in shape, and project from 12 to 20 feet beyond the apron; about 900 tons of rubble-stone was used for this work, together with a large quantity of bowlders and cobble-stone found in its immediate vicinity. This apron-work was commenced in April, 1874, and completed early in August, 1874.

A recent inspection of this sea-wall shows that it is in good condition, and that the rip-rap apron-work and jetties have fully answered the purpose intended.

6.—SEA-WALLS FOR THE PROTECTION AND PRESERVATION OF DEER ISLAND.

Under appropriations made by Congress in 1827, and subsequently, three sea-walls have been built for protecting the three prominent heads

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of this island; that at the North Head being 1,740 feet long, and 19½ feet high above its foundation, and 14 feet above ordinary high-water; that at the Middle Head 840 feet long, 17½ feet high above its foundation, and 12 feet above mean high-water; and that at the South Head 380 feet long, 14½ feet high above its foundation, and 12 feet above mean high-water. These walls were built of regularly split quarried stone, with a partial dressing only, and laid dry as headers, the only backing being the clay and gravel in rear, which, silting out through the open joints, left in course of time large cavities at several places in rear of the walls, resulting in much damage to the walls, with a probability of their entire destruction. To repair the damage already done, and to prevent its recurrence for the future, the rebuilding of these walls was commenced in 1865, by which its several courses, except the lowest, were laid in mortar and backed with concrete, and otherwise much strengthened. This rebuilding was continued until the latter part of 1869, with the following result, as reported by Col. H. W. Benham while in charge of these walls.

The rebuilding of the wall of the Middle Head was completed in 1867, for an extent of 540 feet, all that then appeared to be necessary.

The wall of the South Head was commenced and completely rebuilt in a substantial manner, comprising about 420 running feet, in the year 1867.

The rebuilding of the wall at the North Head was continued until August, 1869, up to which time 1,250 linear feet of wall was taken up, relaid, and completed in rear; two split stone jetties, 25 to 28 feet long, were placed, one at about the middle of the main face of the North Head, and the other in a similar position at the Middle Head wall.

In his report for the fiscal year ending June 30, 1872, Colonel Benham states that the three sea-walls pertaining to these bluffs of Deer Island were "in essentially a good condition, especially in the parts that had been rebuilt; that a few defects are found by the falling or drawing out of the foundation-stones, even, in some cases, of the parts rebuilt, from their not having been taken up to the lowest foundation course, and from the great force of the current or waves along these foundations."

In the latter part of 1873, some repairs were made on the wall at the North Head, and an inspection recently made shows that still further damage has been done to that wall by the gales of March and April last which will have to be repaired.

7.—STRAIGHTENING, WIDENING, AND DEEPENING THE MAIN SHIP-CHANNEL AT THE WEST END OF GREAT BREWSTER SPIT.

This work consists in the removal by dredging of the southern portion of this spit so as to obtain a depth of 23 feet at mean low-water for a width of not less than 600 feet, with proper slopes up to the 18-foot curve. A survey of this locality, made in August, 1872, showed that the extreme westerly end of the spit had so far advanced into the channel that the low-water line was 120 feet further out than it was in 1860, and the 18-foot curve was 168 feet from that of 1860.

Under the appropriation made by act of June 23, 1874, for the improvement of this harbor, a contract was made September 3, 1874, with the New England Dredging Company of Boston, Mass., the lowest responsible bidders, for completing this work. Work was commenced under this contract on the 13th of October and continued until the 29th of October, 1874, when it was suspended for the winter. It was resumed on the 11th of May, 1875, the earliest date practicable, and was con-

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tinued up to the middle of August, 1875. All the dredging to be called for under this contract has been completed, resulting in 29,226 cubic yards. For the entire completion of this contract there remains only the excavation of 112½ cubic yards of sunken ledge, which had been laid bare by the dredging. As preparations had not been made by the contracting party for this unexpected work, operations were suspended upon it until June 1, 1876, when work was again commenced, with a probability of its completion in the month of September, 1876.

8.—STRAIGHTENING, WIDENING, AND DEEPENING THE MAIN SHIP-CHANNEL AT THE SOUTHEAST AND SOUTHWEST POINTS OF LOVELL'S ISLAND.

This work consists in the removal, by dredging, of the Southeast and Southwest Points of this island, so as to give, in "The Narrows," a channel 600 feet in width for a depth of 23 feet at mean low-water, with proper slopes up to the 18-feet curves. Work was commenced on the Southwest Point in 1867, under a contract made with Mr. A. Boschké, of Boston, Mass., and was continued during that and the two following years, until suspended for want of funds. A resurvey of this channel, made in 1872, showed that it had not changed to any considerable extent at its Southwest Point since the close of the dredging operations in 1869; that the 18-feet curve was very nearly the same as then; and that the shore above low-water line had acquired a more natural slope of 8 feet horizontal to 1 foot rise by the receding inland of the high-water line, but that the flats off the *Southeast* Point of this island had advanced so much toward the main channel as to materially impede and endanger navigation.

Under the appropriation made by act of June 23, 1874, for the improvement of Boston Harbor, a contract was made September 8, 1874, with Messrs. Boynton Brothers, of Boston, Mass., the lowest responsible bidders, for completing the work projected for the improvement at the Southeast Point of this island, viz, 40,000 cubic yards, more or less, of dredging, at 38 cents per cubic yard, as measured in the scows. Work under this contract was commenced on the 7th of October and continued until the 17th of December, 1874, when it was suspended for the winter. It was resumed on the 11th of May, 1875, the earliest date practicable, and was completed September 22, 1875, 31,058 cubic yards having been dredged under this contract.

For completing the projected improvement at the Southwest Point of this island, about 40,000 cubic yards of additional dredging will be neccessary, the estimated cost of which, at 40 cents per cubic yard, is $16,000.

9.—STRAIGHTENING, WIDENING, AND DEEPENING THE MAIN SHIP-CHANNEL AT THE UPPER MIDDLE BAR.

The work now projected for the improvement of this bar consists in opening through it a channel, 600 feet in width, to a depth of 23 feet at mean low-water, through a total distance of about 5,500 feet, the principal difficulties being in a space about 2,200 feet in length, in which the depth to be increased varies from 1 to 7 feet. Under a contract made May 20, 1870, with Emory R. Seward, of Albany, N. Y., dredging was carried on at this place until the 1st of June, 1871, at which time 26,120 cubic yards had been excavated under that contract, by which one cut, about 1,800 feet in length, was partially opened to a width of 40 feet, and to a depth varying from 20 to 23 feet at mean low-water.

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Under the appropriation made by act of March 3, 1871, a new contract was made July 29, 1871, with Mr. R. G. Packard, of Brooklyn, N. Y., which was completed June 29, 1872, by 20,305 cubic yards of dredging, making, to that date, an aggregate of 46,425 cubic yards of dredging. By this work, one cut, about 1,800 feet in length, was opened to a width of 40 feet, to a full depth of 23 feet at mean low-water, and a second cut of the same width and depth for a length of 1,040 feet, including the removal of a very large bowlder discovered in 1872, in the main ship-channel, with but 16½ feet of water upon it at mean low-water.

Under the appropriation of March 3, 1873, a contract was made March 5, 1874, with the Atlantic Dredging Company, of Brooklyn, N. Y., for 75,000 cubic yards, more or less, of dredging, at 64 cents per cubic yard, as measured in the scows, and at $3.35 per cubic yard for excavation of ledge, and of bowlders exceeding 6 tons in weight. Operations were commenced in April, 1874, and were continued up to the 14th of December, of that year, when they were suspended for the winter. On the 26th of May, 1875, they were resumed, and continued up to the 17th of December, of that year. They were again resumed on the 3d of May, 1876, and have been continued up to the end of the fiscal year, (June 30, 1876,) at which time 89,375 cubic yards had been dredged under this contract.*

Under the appropriation made by act of June 23, 1874, for continuing the improvement of this harbor, a contract was made September 1, 1874, with the Harbor Improvement Company of Boston, Mass., for 42,000 cubic yards of additional dredging on this bar, at 85 cents per cubic yard, as measured in the scows. Dredging was commenced under this contract on the 3d of October, and continued until the 14th of December, 1874, when it was suspended for the winter. It was resumed on the 8th of May, 1875, and continued up to the 17th of December, 1875, at which time 42,843½ cubic yards had been dredged under this contract. There now remains to be done, for the completion of this contract, the excavation of 37 cubic yards of ledge, which will probably be completed in July.

Under the appropriation made for this harbor by act of March 3, 1875, a contract was made May 19, 1875, with Messrs. Curtis, Fobes & Co., of Portland, Me., for 90,000 cubic yards, more or less, of additional dredging on this bar and the shoals below it, at 75 cents per cubic yard, as measured in the scows, including bowlders not exceeding 6 tons in weight, and for excavating ledge or bowlders exceeding 6 tons in weight at $3.35 per cubic yard; the work to be completed on or before the 30th of September, 1876. Operations were commenced under this contract May 9, 1876, and have been continued since then, resulting in 24,014½ cubic yards of dredging.

The total quantity of dredging, therefore, that has been done up to date under the several contracts named amounts to 202,658 cubic yards, whereby a channel has been opened for an average width of about 450 feet and a depth of 23 feet at mean low-water through the shoalest portion of the Upper Middle Bar, averaging in length about 2,200 feet.

In order to complete the projected channel at the Upper Middle Bar, it will be necessary to provide for about 25,000 cubic yards of dredging, in addition to that which remains to be done under the three unfinished contracts, the estimated cost of which, at 75 cents per cubic yard, is $18,750.

* This contract was completed on the 11th of July, 1876.

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10.—REMOVAL OF NASH'S ROCK, (SHOAL.)

Nash's Rock, so called, is a shoal lying in the outer entrance to Boston Harbor, about one-third of the way over from Brewster Spit to Point Allerton. This shoal was surveyed in September and October, 1873, and a special report thereon, accompanied by drawings, was submitted to the Department on the 24th of March, 1874. From information acquired by this survey, it is seen that the only portion of this shoal which it would be advisable and practicable to improve is that having less than 21 feet of water over it at mean low-water, which portion has an area of 637½ superficial yards, and would require, in order to obtain a depth of 21 feet, the excavation and removal of about 200 cubic yards of bowlders, shingle, &c., at an estimated cost of $5,000; whereas to remove the whole shoal to a depth of 23 feet below the plane of mean low water would require the excavation of over 16,000 cubic yards of similar material over an area $9\frac{1}{16}$ acres, the cost of which would be greatly disproportionate to the benefit that would result therefrom.

Under the appropriation made by act of March 3, 1875, for the improvement of this harbor, a contract was made May 19, 1875, with Messrs. Curtis, Fobes & Co., of Portland, Me., for removing this shoal to the projected depth of 21 feet at mean low-water on terms as follows, viz:

a. For 200 cubic yards, more or less, of gravel, shingle, &c., (including bowlders not exceeding 6 tons in weight,) at $5 per cubic yard, as measured in the scows; and

b. For bowlders exceeding in weight 6 tons, (of 2,240 pounds,) at $35 per ton.

This work is to be completed on or before the 30th of September, 1876.

11.—REMOVAL OF KELLY'S ROCK.

This rock lies in the main ship-channel, distant about 700 yards, in a direction southeast by south of Bug light, (at the Narrows,) and in the line of entrance-buoy No. 1 and Bug light. In 1869, operations were commenced for removing this ledge to a depth of 23 feet below the plane of mean low-water, and were continued up to the end of December, 1870. These operations were continued in June and July, 1873. An accurate survey, since made, of this rock showed that there still remained an area of about 320 superficial yards of this ledge which has less than the projected depth on the shoalest parts, of which there were but 21.2 feet of water at mean low-water, and that in order to obtain the full depth of 23 feet would require the removal of not less than 80 cubic yards of the ledge.

Under the appropriation made by act of March 3, 1875, for this harbor a contract was made May 14, 1875, with Mr. George W. Townsend, of Boston, Mass., for completing the removal of this rock at $60 per cubic yard. He commenced operations under this contract in the latter part of May and completed it September 30, 1875.

During the removal of this rock in 1875 new ledges were discovered in its vicinity, above and below, having on the shoalest parts a depth of but 20 to 21 feet at mean low-water. These ledges cover an area of about 543 square yards in the 23-feet plane below mean low-water, and 189 cubic yards will have to be removed above that plane, the estimated cost of which, at $60 per cubic yard, is $11,340.

12.—REMOVAL OF TOWER ROCK.

This rock was situated in the main ship-channel at the Narrows about 100 yards to the southwest of Great Brewster Spit light. It was

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blasted out and removed in 1867 to the projected depth of 23 feet at mean low-water.

13.—REMOVAL OF CORWIN ROCK.

This rock was situated in the main ship-channel at the Narrows, about 200 yards to the southwest of Great Brewster Spit light. It was blasted out and removed in the years 1868 and 1869 to the projected depth of 23 feet at mean low-water.

14.—REMOVAL OF SUNKEN LEDGE, BETWEEN GEORGE'S ISLAND AND GREAT BREWSTER SPIT.

This ledge was discovered in September, 1872, in a resurvey of the Narrows. It was situated near the middle of the main ship-channel, directly in the track of all large vessels, and particularly of the European steamers, and was distant 317 yards in a direction west by south from Bug light. It had but 18.9 feet of water upon it at mean low-water, and was, therefore, a dangerous obstacle to navigation.

Under the appropriation of June 23, 1874, a contract was made August 31, 1874, with Mr. William H. Lloyd, of Boston, Mass., for the removal of this ledge to a depth of 23 feet at mean low-water—altogether 16⅛ cubic yards—for the sum of $400, which he completed early in September, 1875.

15.—REMOVAL OF BARREL ROCK, IN BROAD SOUND.

This was a bowlder lying about one mile a little north of west from Green Island, and near the sailing-line of the Portland and other Maine steamers. It had only 4 feet of water over it at low-tide, and in thick weather was a dangerous obstacle to navigation. It was removed in 1869.

16.—REMOVAL OF STATE AND PALMYRA ROCKS.

A special survey was made of these rocks, of which a report and drawings were transmitted to the Department on the 25th of May, 1874. By this survey it was ascertained that State Rock and Palmyra Rock, of the position and character of which but little previously had been known, are situated very near each other, and most probably are outcroppings of the same ledge, forming spurs on the southern side of the Lower Middle Bar, about one-half a mile east of Castle Island.

To effect the improvement proposed required altogether the removal of about 62 cubic yards of rock, for which a contract was made, August 31, 1874, with Mr. William H. Lloyd, of Boston, who was the lowest of two bidders, at $1,500 for the job. Mr. Lloyd commenced work upon the removal of the rocks in September, 1874, and continued up to the middle of November, when, on account of the weather, he was obliged to suspend for the winter. He resumed work about the 1st of June, 1875, and completed their removal on the 15th of that month.

17.—THE REMOVAL OF THE WRECK OF THE SCHOONER DELOS.

This was an old vessel, of about 100 tons burden, deeply loaded with gravel in her hold and on deck, destined for the engineer-work at Fort Warren, and was sunk in the gale of November 12, 1872, in Nantasket Roads, about 100 yards from Fort Warren wharf, in about 22 feet of water at low-water. When examined in December, 1872, she was stripped of her masts and rigging, and was much shattered, and had

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about 14 feet of water over her at mean low-water. The breaking-up and removal of this wreck was commenced on May 29, 1873, and was completed in the early part of June.

From the foregoing statement it is seen that nearly all the works hitherto projected for the improvement of Boston Harbor have been completed, and that those remaining to be completed are—

1. The removal of a recently discovered ledge near the southwestern extremity of Great Brewster Spit. Work has been commenced upon this ledge by contract, and it is probable that it will be completed in September, 1876;

2. About 40,000 cubic yards of dredging at the Southwest Point of Lovell's Island, in order to obtain the contemplated width and depth of channel, for which no funds are now available;

3. About 90,000 cubic yards of dredging at the Upper Middle Bar, for obtaining a channel to the projected width of 600 feet and a depth of 23 feet at mean low-water. A contract was made for 65,000 cubic yards of this dredging to be completed this season, leaving only 25,000 cubic yards to be provided for by future appropriations;

4. Removal of Nash's Rock, (Shoal.) This work has not yet been commenced; but a contract has been made requiring it to be completed on or before the 30th of September next;

5. The removal of about 189 cubic yards of sunken ledge, discovered in 1875, in the vicinity of Kelly's Rock, for which no funds are now available.

In addition to the above, the southeastern sea-wall on Lovell's Island will require raising and repairing, and some few repairs are needed by the sea-walls on Great Brewster Island and Deer Island, for which no funds are now available.

In the appropriation for this harbor, made by act of Congress approved March 3, 1875, provision was made for the improvement of Hingham Harbor, Massachusetts, to an extent not exceeding $10,000. A careful survey of this harbor made in October and November, 1874, showed the nature and extent of the improvements required for the commerce of that place, the project for which consisted in widening and deepening the channel so as to have a width of not less than 100 feet and a depth of 8 feet at mean low-water, or about 6 feet at low-water in spring tides. For this improvement the following work has been done, viz, 25,160 cubic yards of dredging and 80 cubic yards of ledge excavation. Proposals were invited for this work and contracts therefor were made as follows, viz:

1. With Messrs. Curtis, Fobes & Co., of Portland, Me., May 19, 1875, for the dredging, at 18 cents per cubic yard, which they completed on the 1st of May, 1876.

2. With Mr. George W. Townsend, of Boston, Mass., for 67 cubic yards ledge-excavation, at $39 per cubic yard, which he completed in December, 1875.

In addition to the above, about 12 cubic yards of sunken ledge, subsequently discovered, has been removed, whereby all the work projected for the improvement of this harbor has been completed, at a total cost (including contingencies) of $9,116.58.

The following is an estimate of the cost of completing the several works yet remaining to be done (as above) for the improvement of Boston Harbor, viz:

1. The removal of 112½ cubic yards of ledge near the southwestern extremity of Great Brewster Spit, at $43 per cubic yard, as contracted for, including $2,263.63 percentage retained, and amount due on work done up to July 1, 1876..... $7,181 08

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2. 40,000 cubic yards dredging, not yet contracted for, at the southwest point of Lovell's Island, at 40 cents per cubic yard		$16,000 00
3. Completing the channel through the Upper Middle Bar:		
a. 1,000 cubic yards of dredging, at 64 cents per cubic yard, as per contract of March 5, 1874, (including $11,463.25 percentage retained on work done up to July 1, 1876)	$12,103 25	
b. Removing 37 cubic yards of sunken ledge at $45 per cubic yard, under contract of September 1, 1874, (including $2,283.38 percentage retained on work done up to July 1, 1876)	3,848 38	
c. 65,000 cubic yards dredging, at 75 cents per cubic yard, as per contract of May 19, 1875, (including $1,801.02 percentage retained on work done up to July 1, 1876)	50,551 02	
d. 25,000 cubic yards dredging, not contracted for, at 75 cents per cubic yard	18,750 00	
		85,252 65
4. Removal of Nash's Rock (shoal) as per contract of May 19, 1875		5,000 00
5. Removal of 189 cubic yards near Kelly's Rock, at $60 per cubic yard		11,340 00
6. Raising and repairing sea-wall on Lovell's Island (new estimate)		15,000 00
Add for engineering expenses and other contingencies, say		15,681 56
Total		155,455 29
Amount available July 1, 1876		80,455 29
Additional amount required for completing all the work now projected for the improvement of Boston Harbor		75,000 00
Amount asked for in annual report for fiscal year ending June 30, 1875		60,000 00
Additional amount required for raising and repairing sea-wall on Lovell's Island, (new estimate,) as above, item 6		15,000 00
Total		75,000 00

On comparing the original estimate of the cost of the several works proposed to be done in 1866, as then submitted, with the actual cost of the same as now finished, it will be seen that the actual cost has been about 50 per cent. higher than the original estimate, which excess is probably owing to the want of exact data upon which to base that estimate, as well as to the price of material and labor having been assumed too low; and for other completed works no detailed estimates appear to have been submitted; while for a greater part of the works since projected from time to time, those completed have generally cost about the same as estimated.

The several works built for the improvement of this harbor lie within the port of Boston, and in the collection-district of Boston and Charlestown, Mass.

The value of the imports into this port for the fiscal year ending June 30, 1876, as furnished by the United States collector of customs, was $37,413,496, and the amount of duties received for the same period was $14,233,196.01.

The amount of tonnage which entered and cleared foreign, for 11 months ending May 31, 1876, was as follows, viz: Cleared, foreign, 526,057 tons; entered, foreign, 562,086 tons.

Money statement.

Amount available July 1, 1875	$191,930 78
Amount expended during fiscal year ending June 30, 1876	111,475 49
Amount available July 1, 1876, including $17,811.28 due on contracts	80,455 29
Amount appropriated by act approved August 14, 1876	50,000 00
Amount (estimated) required for completion of existing project	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	25,000 00

A 14.

IMPROVEMENT OF PLYMOUTH HARBOR, MASSACHUSETTS.

The existence of this harbor depends entirely upon the protection and preservation of Long Beach, which is a narrow strip of land that extends

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2¾ miles out from the main land in a northwesterly direction, nearly parallel to the shore of the town of Plymouth, and distant from it about 1 mile. It affords to the harbor its only shelter from easterly storms. In late years it has been washed away in some places, and much weakened in others, to an extent seriously threatening the ruin of the harbor. For the protection and preservation of this beach, various works have been built from time to time, until finally they have proved efficient and successful.

The total amount that has been appropriated by Congress for the preservation and improvement of this harbor, from 1824 up to and including 1875, as shown by statement furnished under date of February 1, 1876, by the Chief of Engineers, for the information of the Committee on Commerce of the House of Representatives, is $97,766.

Of this amount there has been allotted to and appropriated for this harbor, since the resumption of works on rivers and harbors, in 1866, the sums as follows, viz:

Amount allotted in 1866 from appropriation made for harbors on the Atlantic coast	$8,300 00
Amount allotted under act of July 25, 1868	7,500 00
By act approved July 11, 1870, appropriated	10,000 00
By act approved March 3, 1871, appropriated	10,000 00
By act approved June 10, 1872, appropriated	2,500 00
By act approved March 3, 1873, appropriated	3,000 00
By act approved June 23, 1874, appropriated	5,000 00
By act approved March 3, 1875, appropriated	10,000 00
Total	56,300 00

In 1866, under the allotment of $8,300 for Plymouth Harbor, a wooden breakwater was built, by contract, in that year, for the protection of Long Beach, under the charge of Maj. Jared A. Smith, Corps of Engineers. In the annual report for the fiscal year ending June 30, 1867, it is stated that—

> One thousand three hundred linear feet of that breakwater had been built. It consists of triangular frames placed at intervals of 4 feet, covered with 2-inch plank, set in a trench 12 feet wide and 3 feet deep, the trench and frame being filled to the level of the ground. It is situated on the crest of a ridge of sand, of about 3 miles in extent, and of an average width of 800 feet. At intervals along this ridge there are depressions, through which the sea breaks with great violence. It is in these intervals that the breakwater is placed.

In 1867 other work was added by the State of Massachusetts, at an expense of about $2,000.

> These works were then deemed sufficient to resist any action of the sea; but a storm in the autumn of 1867 carried away some of the more exposed portions, and a second occurring the subsequent winter, when tides were highest, carried away about 1,000 linear feet of the strongest portion of the work, besides doing other damage, leaving the northern portion of the beach, adjacent to the main entrance of the harbor, entirely unprotected from the open sea, save by some remaining portions of a work completed in 1832, and the beach itself so much reduced as to be entirely submerged, at extreme high tides, for a length of 1,500 feet. The sand was such that, while a slight action of the sea would raise the beach, the prevailing winds and heavier seas would drive the sand into the channel, and it was evident that a severe storm would not only seriously injure the beach thus unprotected, but also the main channel, and leave it entirely exposed to further encroachments.

Under an additional allotment of $7,500 made in August, 1868, out of the appropriation of July 25, 1868, 200 linear feet of substantial cribwork of timber covered with plank, and 175 linear feet of triangular work (similar to that built in 1866) were built by contract in the autumn of 1868, for the further protection of Long Beach where injured by the storms of the previous autumn, Major Smith having been in charge of the work.

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Under the appropriation of $10,000 made by act of July 11, 1870, a contract was made by the late Lieut. Col. J. G. Foster, Corps of Engineers, then in charge of the work, for the construction near the outer end of Long Beach of about 1,700 linear feet of bulk-head and jetties, built of frame-work and filled with brush and ballasted with stone. This work was commenced in September, 1870, and completed before the close of that season.

In May, 1871, the charge of Plymouth Harbor improvement was transferred to Lieut. Col. George Thom, Corps of Engineers, by whom contracts were made under the appropriation of March 3, 1871, for completing the projected bulk-head and jetties on the extremity of Long Beach, at $3.86 per linear foot, and for furnishing and placing granite grout upon the stone bulk-head to connect the outer end of the beach with the beacon, at $2.25 per ton. Work was commenced under both contracts in June, 1871; that on the brush bulk-head and jetties was finished in August, 1871, 641½ linear feet having been built under the contract; and the contract for the stone was completed in September, 1871, 2,028 tons having been furnished. The balance of the appropriation of 1871 was applied to the repairs of the bulk-head and jetties previously built upon Long Beach, in places where they had been damaged by storms, and to the planting of beach grass on the beach where most necessary for its preservation.

Under the appropriation of June 10, 1872, ($2,500,) the following repairs were made in July and August of that year, viz:

1. In making about 200 linear feet of brush bulk-head and jetties, to replace that damaged by the storm in November, 1871;
2. In strengthening the outer part of the bulk-head with 613 tons of stone, purchased for that purpose;
3. In making 300 linear feet of single brush jetties, and 250 linear feet of small stone jetties; and,
4. In planting 10,800 hills of beach-grass.

This work was done by hired labor and with materials purchased in open market, as authorized so to do.

The appropriation of $3,000 made by act of March 3, 1873, was applied to continued repairs upon all the works previously built, to the building of stone and brush groins outside and inside the bulk-head at the outer end of Long Beach, and to planting over 10,000 hills of beach-grass on the newly-formed beach, and in other places where most necessary.

The appropriation of $5,000 made by act of June 3, 1874, was applied to the completion of all the stone and brush groins on the outer end of Long Beach; to increasing in height and strength the stone bulk-head connecting the beacon with the outer end of the beach; to building a small bulk-head of frame-work, brush, and stone, 290 feet in length, for protecting the beach about one mile from its inner end; to planting beach-grass, and making repairs where most necessary for the protection and preservation of Long Beach. This work was done by hired labor and with materials purchased in open market, and was completed in August, 1875.

From the foregoing it is seen that the several amounts that have been allotted to and appropriated for the improvement of Plymouth Harbor since 1866 have been applied to the construction of bulk-heads, jetties, and groins, and the planting of beach-grass where most necessary for protecting and strengthening Long Beach throughout its whole extent of about 2¾ miles.

These bulk-heads consist of triangular frames, (built in 1866 and 1868,)

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or of crib-work of timber covered with plank, (built in 1868,) and those built in 1870 and 1871 of a frame-work well secured in the ground, filled with brush, and ballasted with stone; that connecting the outer end of the beach with the beacon being built entirely of rubble-stone.

The jetties consist of a frame-work filled with brush and ballasted with stone, and the groins of small stones intermixed with brush, and sometimes of brush alone. These groins, 33 in number, are built out perpendicularly from the main bulk-head, on the seaward side, varying in length from 75 to 265 feet, and aggregating 5,250 feet in length, and from 50 to 150 feet apart. Others have been built inside the bulk-head, in places where most necessary. They were made by placing brush upon the surface of the beach and piling upon it beach-bowlders to a height of about 2 feet and for a width of 5 feet. The brush groins were made by digging a trench 2 feet by 2 feet, and placing brush in it upright and as close as practicable, the brush being held by sand being thrown into the trench and well rammed down, and sometimes further protected by small bowlders placed in a row along the sides of the groin. The brush rises about 2 or 3 feet above the surface of the beach.

The bulk-heads and jetties had already accumulated a large quantity of sand, forming a ridge throughout its whole extent; but with a view to increasing its strength and efficiency, the several groins have been built, and have fully answered the purpose for which they were intended. Beach-grass has been planted, and covers nearly all this newly-formed beach, which is now in an efficient condition. Repairs will, however, continue to be necessary from time to time, as they now are, along this beach, exposed as it is to injury by violent storms. Something more should also be done for increasing the efficiency of the stone bulk-head at the outer end, and its connection with the beach, the estimated cost of which is as follows, viz:

1. 1,000 tons rubble-stone, at $2	$2,000 00
2. Repairs of bulk-head near inner end of beach, (partially burnt of late)	250 00
3. Repairs of bulk-head and jetties	750 00
Adding for contingencies, say	500 00
Total	3 500 00

A survey was made of this harbor in February, 1874, by Mr. Sophus Haagensen, assistant engineer, in compliance with a resolution of the House of Representatives dated December 10, 1873, "with a view to dredging and improving the same, so as to afford greater protection and facilities to commerce."

To make this portion of the harbor practicable for "beating up" with sailing-vessels would require a width of not less than 500 feet, which would necessitate the excavation of about 80,000 cubic yards of hard sand on the "Middle Ground" and "Splitting Knife" Bars, which obstruct the present channel, and about 320,000 cubic yards of mud and clay between the "Middle Ground" and "Long Wharf," at a probable cost of not less than $176,000, and with a likelihood that the improvement would be but temporary, as the same causes which have already produced the existing shoals would, it is more than probable, reproduce them. Should it be decided to improve this harbor by dredging, it is recommended that it should be applied to the opening of a channel 100 feet in width and 6 feet in depth at mean low-water, from the end of Long Wharf outward in continuation of the present main channel above the Middle Ground. A channel of this width would enable vessels to be towed up to the vicinity of the wharves of the town, and would probably be kept open by the scour of the ebb-tide deflected into it from "Town Brook."

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The estimated cost of this channel was as follows, viz:

64,000 cubic yards dredging, at 40 cents per cubic yard	$25,600 00
Add for contingencies, say	2,400 00
Total	28,000 00

Under the appropriation of $10,000, made by act of March 3, 1875, for improving this channel as above projected, a contract was made May 13, 1875, with Mr. Augustus R. Wright, of Geneva, N. Y., the lowest bidder, at 23 cents per cubic yard, as measured in the scows, for 35,000 cubic yards, more or less, of dredging, to be applied to the partial excavation of the projected channel. Dredging was commenced under this contract on the 19th of April, 1876, and was completed on the 21st of June, 1876, resulting in 34,985 cubic yards of dredging, whereby a channel was opened up to wharves of Plymouth for a width of 50 feet and to a depth of 6 feet at mean low-water.

After further considering the wants of commerce and the facilities required, it is recommended that a basin be excavated at the upper end of the channel in front of the wharves, where vessels may lie secure and be able to pass each other at any stage of the tide. Here it now averages 1 foot bare at mean low-water, and it is recommended that the basin be excavated to a depth of 8 feet at mean low-water for an area of 12,500 square yards, which would require about 45,000 cubic yards of dredging in addition to that called for in the estimate submitted in February, 1874. With this modification in the project, the following estimate is submitted for completing the improvement of this harbor, viz:

1. 30,000 cubic yards dredging for completing channel, as per original estimate, at 30 cents per cubic yard	$9,000 00
2. 45,000 cubic yards additional, for basin, at 30 cents per cubic yard	13,500 00
Adding for contingencies, say	4,327 42
Total	26,827 42
Adding to this the above estimate for continuing the works for the protection and preservation of Long Beach	3,500 00
Total	30,327 42
Amount available July 1, 1876	327 42
Additional amount required for the fiscal year ending June 30, 1878	30,000 00

Money statement.

Amount available July 1, 1875	$11,075 67
Amount expended during fiscal year ending June 30, 1876	10,748 25
Amount available July 1, 1876	327 42
Amount (estimated) required for completion of existing project	30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	30,000 00

A 15.

IMPROVEMENT OF PROVINCETOWN HARBOR, MASSACHUSETTS.

The following amounts have been allotted to and appropriated for the preservation of this harbor since the resumption of work on rivers and harbors in 1866, viz:

Amount allotted in 1866, from appropriation made for harbors on the Atlantic coast	$15,000 00
Amount appropriated by act approved June 23, 1866	43,068 44
Amount allotted under act approved April 10, 1869	9,000 00

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Amount appropriated by act approved March 3, 1871	$6,000 00
Amount appropriated by act approved June 10, 1872	5,000 00
Amount appropriated by act approved March 3, 1873	6,000 00
Amount appropriated by act approved June 23, 1874	6,000 00
Amount appropriated by act approved March 3, 1875	5,000 00
Total	95,068 44

Under the above appropriations, the following work has been done to date, for the preservation of this harbor, viz:

1. Bulk-heads and jetties of various descriptions have been built from time to time along Beach Point for its preservation and protection, both by the United States Government and by the local authorities.

2. A dike was built in 1868 and 1869 by the State of Massachusetts across the outlet of East Harbor Creek.

3. A dike was built in 1868 and 1869 by the United States Government across East Harbor Creek at the Wading Place, near High Head, about 2 miles above the outlet of the creek.

4. Wooden bulk-heads and jetties have been built at different times for the protection and preservation of the beach on Long Point.

5. A stone bulk-head has been nearly completed for the protection and preservation of the outer end of Long Point, the light-house, and Three-gun Battery.

6. A substantial dike (272 feet in length) was built in 1871–'72 across the head of Lancey's Harbor, near Abel Hill.

7. Beach-grass planted on Beach Point, Long Point, Abel Hill, Cove Section, and Oblique Section, and at the last two places brush has also been laid for their further protection.

8. The projected extension of the several jetties on Beach Point and State Dike has been completed.

9. A bulk-head and 6 jetties built for the preservation and protection of the beach at Cove Section, near High Head, where encroached upon by the extraordinary gales of November, 1873, and January, 1874. This bulk-head is 607 feet in length, and the jetties have an aggregate length of 126 feet. They consist of a frame-work filled with brush and ballasted with stone, and were completed in December, 1874.

10. Accurate resurveys made in 1871, '72, '73, and '74 of Cove Section, Oblique Section, Beach Point, and Long Point, together with elaborate soundings and current observations in the inner harbor.

On the 1st of July, 1875, there was available for the further improvement of this harbor the sum of	$3,326 07
Amount expended during the fiscal year ending June 30, 1876	2,830 00

The amount expended during the fiscal year ending June 30, 1876, has been applied to the completion of the sluiceway and other repairs of High Head dike; to strengthening and extending the bulk-head and jetties at Cove Section; repairing bulk-head and jetties on Beach Point; extending the stone bulk-head on Long Point, and planting beach-grass at Cove Section, Oblique Section, Beach Point, Long Point, and on the sand-hills between Beach Point and Cove Section. A resurvey made of Cove Section in August, 1875, showed that since the completion of the bulk-head and jetties in December, 1874, the sand had accumulated in front of those works to so great an extent that the beach had been raised 4 feet on an average between the works and the crest of 1874, and that outside the crest of 1874 the sand had accumulated to an increased height of 11 feet, throwing outward the high and low water lines respectively 90 feet and 105 feet since 1874. A recent inspection of the work showed continued improvement to such an extent that it is believed

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that this weak portion of the beach is now secure against further encroachment by storms. These works, however, as well as the dikes at High Head and Abel Hill and others built for the preservation of this harbor, require continuous watching and repairs. The stone bulk-head also on the extremity of Long Point should be extended further up the beach, as well as around the extremity of the point, to insure its preservation, as well as that of the light-house built upon it. The following is an estimate of the cost, viz:

1. Raising and extending the stone bulk-head for the protection and preservation of Long Point, near the light-house, and Three-gun Battery; 1,500 tons rubble-stone, at $2	$3,000 00
2. Repairs of bulk-head and jetties on Beach Point and Cove Section	250 00
3. Repairs of dikes at High Head and Abel Hill	250 00
4. Planting beach-grass for preserving and strengthening the "outer beach"	600 00
Adding for contingencies, say	1,396 00
Total	5,496 07
Amount available July 1, 1876	496 07
Additional amount required for fiscal year ending June 30, 1878	5,000 00

In regard to the estimates for the work done for the preservation of this harbor they appear to have generally agreed with the amounts that have been appropriated and expended therefor. Much of the work, however, has been for repairs and extensions not foreseen, but absolutely necessary to be made as they occurred, for which no previous estimates could be made.

Further and more detailed information in regard to the history and description of the several works built for the preservation of this harbor will be found in the accompanying paper of Assistant Engineer Sophus Haagensen, with drawings illustrating same, which has been prepared and completed under my direction, principally from reports and drawings in this office.

Provincetown is a port of entry within the collection-district of Barnstable, Mass.

The amount of revenue received at this port during the fiscal year ending June 30, 1876, was $1,637.89.

The number of vessels engaged in coasting trade and foreign trade which resorted to this harbor for refuge and trade during that year, (as stated by the deputy collector of customs at that port,) from the best available information, was estimated to be 7,500, having an aggregate tonnage of 525,000 tons, worth $20,000,000, and carrying cargoes of the value of $2,500,000.

Money statement.

Amount available July 1, 1875	$3,326 07
Amount expended during fiscal year ending June 30, 1876	2,830 00
Amount available July 1, 1876	496 07
Amount appropriated by act approved August 14, 1876	4,000 00
Amount (estimated) required for completion of existing project	1,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	1,000 00

REPORT OF MR. SOPHUS HAAGENSEN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Me., March 23, 1876.

GENERAL: In accordance with your directions, I have the honor to herewith submit to you a description of the works built for the protection and preservation of Provincetown Harbor, Mass., together with four plans illustrating the same, compiled from the various sources of information in this office.

LOCALITY.

Provincetown Harbor is situated at the extremity of Cape Cod, in latitude 42° 02′ north, and longitude 70° 10′ west. It is one of the most important harbors of refuge on the Atlantic coast, and its location, easy accessibility, and completely protected anchorage entitle it to be called the model harbor of the Atlantic coast.

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Its usefulness as a harbor of refuge is demonstrated by the large fleet of vessels always to be found there in rough weather. Coasters, the numerous vessels engaged in fisheries on George's Banks, (115 miles distant,) and foreign vessels bound into ports in Massachusetts, all find it a convenient rendezvous in stormy weather. In offering to vessels of the latter class a safe retreat when suddenly overtaken by storms in Massachusetts Bay, under circumstances where their approach to the entrance of Boston Harbor would be dangerous, it largely enhances the value of this port.

EASY ACCESSIBILITY.

Provincetown Harbor is easy of access, and the only dangers are the sand-flats, known as Shank Painter Bar, Wood End Bar, and Long Point Bar, the first two of which extend about one-half a mile from the shore, the latter about one-quarter of a mile; but there is ample room to give these shoals a wide berth, even in a northeast wind, the most unfavorable for entering the harbor.

LIGHTS.

The 4 lights, viz: Highland light, Race Point light, Wood End light, and Long Point light afford guides for its entrance at night. On entering the harbor, when Long Point light bears south, good anchorage is found in 13 fathoms of water or less.

SAFE ANCHORAGE.

The holding-ground is good; it consists of mud, more or less stiff, in depths exceeding 8 fathoms; in lesser depths the bottom is clear hard sand.

The harbor is completely land locked; lines drawn from the middle of the harbor to all points of the compass strike land within a distance of five miles, this maximum distance being in a direction east-southeast. The harbor is therefore free from a heavy swell in all gales.

CAPACITY.

Its capacity is of the very largest. Limiting the harbor proper to the area west of a line drawn between Long Point light and Mount Ararat, the following figures give the areas of various depths, viz:

	Square miles.
Area in the plane of high-water	3.67
Area in the plane of low-water	2.32
Area in the plane of 6 feet below low-water	1.79
Area in the plane of 12 feet below low-water	1,54
Area in the plane of 18 feet below low-water	1.06

or for vessels of 9 feet draught and upward there is an area available for anchorage at all stages of the tide of 1¾ square miles, or 1,067 acres.

TIDE.

The mean rise and fall of tide is 9.2 feet, and the plane of mean low-water in the harbor (the plane of reference) is 30.17 feet below the bench on the southeast corner of Centenary church, the top of brick-work junction with wood.

MAP OF THE HARBOR.

The attention of the Government was early called to the value of this harbor. In the years 1833, 1834, 1835 elaborate surveys were made of the extremity of Cape Cod by Maj. J. D. Graham, United States Topographical Engineers, and a map thereof published minutely explaining the peculiar feature of this interesting harbor.

CHARACTER OF MATERIAL INCLOSING THE HARBOR.

The material of the cape forming the harbor consists entirely of sand washed up by the sea and blown into dunes by the wind. Outside and to the westward of High Head (the terminus of the gravel and clay formations) nothing but pure sand is found, even to great depths. Borings made for water in Provincetown have disclosed the fact that clay was not struck till a depth of 180 feet below low-water mark was reached.

This sand, being entirely free from any binding matter, is subject to great changes by even moderate actions of sea and wind.

THE OUTER BEACH.

The only barrier between the ocean and the harbor was, at the time of Major Graham's survey, a low sand beach, called the "Outer Beach," which at the point designated as "Cove section" was only 300 feet wide between the high-water lines either side of it. This beach was exposed to the most violent action of the ocean, the effect of which was known for years to be the abrasion of the entire easterly coast of Cape Cod, resulting at Chatham in the destruction of that harbor.

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The immediate danger of a breach through this weak barrier, which, for reasons afterward to be commented upon, would inevitably cause the destruction of Provincetown Harbor, was perhaps the main reason why the Government took in hand the preservation of Provincetown Harbor. To give a brief history of the works built for this purpose is the object of this paper.

The only means of communication with Provincetown as late as 1855 was by land along the above-mentioned sand-beach, necessitating a ride of four miles through loose, drifting sand. At low-water about half of this ride could be avoided by crossing East Harbor Creek below High Head, in the locality known as the "Wading-place," now the site of the United States dike.

An improvement in this route of travel was made in 1855, when the bridge across the entrance to East Harbor was built, joining Beach Point with the opposite shore.

BEACH POINT.

Beach Point, which at the time of Major Graham's survey was entirely elevated above the highest tides, suffered subsequently by the wash of the waves in southwest gales, until the water broke through about one-half a mile southeast of the bridge shortly after its completion.

WORKS OF REPAIR.

At the joint expense of the county of Barnstable and the town of Truro, two plank bulk-heads were built along the beach for the purpose of inclosing a roadway; and various jetties projecting at right angles from the beach were also built by the same parties in order to preserve this roadway.

But no permanent improvement of this beach was effected until the United States Government took the matter in hand, and erected a system of brush bulk-heads and jetties, which have in every respect accomplished the purpose for which they were intended. In addition to which a dike was built by the State of Massachusetts, whereby the entrance to East Harbor was closed, and the beach extended to the main land, near Mount Ararat.

These improvements have been so successful, that the Old Colony Railroad has since built their track on this beach, in extending the road from Boston to Provincetown.

BRUSH JETTIES.

The construction of brush bulk-head and jetties will be understood from Plate II, Fig. 4. They consist of wooden posts, averaging 11 feet in length and 8 inches in diameter; these are set 5 feet deep into the sand, in 3 rows, 4 feet apart, and at equal distances of 4 feet in each row. Trenches are dug to admit of putting on longitudinal and transverse braces 2 feet below the surface of the beach. Above the beach two more systems of braces hold the tops together. This frame-work is then ready to receive the brush, the ends of which project outside the face of the frame. The brush is properly ballasted with bowlders weighing from 50 to 150 pounds. The outer ends of the more exposed jetties have been protected by a stone apron; and in cases where the jetty approached the low-water line, and the sand was very movable, a plank floor 1¼ inches thick has been laid upon the lower transverse braces and ballasted, in order to keep the posts from being lifted out by the rising tide.

This work was commenced in 1866 at the above-mentioned breach, ¼ mile from the extreme end of Beach Point. As early as 1869 the wasted beach had been so restored and increased in strength, that the Massachusetts State board of commissioners on the building of the dike across East Harbor Inlet adopted the same plan, in order to restore the outer bank of the dike then completed, which had been abraded to such an extent by the violent gales of September and October, 1869, "as made it imperative that some work should be done to repair the breaches and arrest further action in the same direction."

The repair and further extension of these jetties has since been done by the United States Government.

The bulk-head is built immediately below the high-water line and the jetties perpendicularly to it on the beach, the slope of which averages 1 foot in 10 feet, although in some places it is only 1 in 7. The length of the jetties vary from 40 feet to 70 feet. In all, 7,170 running feet of bulk-head and jetties have been built on Beach Point, and their effect has been to add 200,000 cubic yards of sand to this beach. The jetties east of the State dike are all buried in the sand; those in front of the dike are as yet only partially so, but the sand is rapidly accumulating there.

Numerous stone-groins ballasting the accumulated sand have also been constructed in this locality

The superiority of brush-work over all other constructions built as "catch-sands" is due to the uneven surface presented by the brush to the dash of the waves, deadening the shock of the water, and preventing the receding water from undermining the structure. These brush-work bulk-heads and jetties have proved to be highly successful in the restoration of Long Beach, Plymouth Harbor, Mass., where numerous and far costlier works, triangular and square crib-works, ballasted with stone, and even solid stone walls, had failed to retain the sand carried in by the surf.

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DANGER FROM AN INLET ON THE EAST SIDE AT COVE SECTION.

During the progress of repairing Beach Point, the wearing away of the outer beach continued steadily, so that a breach at Cove section might be expected in any violent northeast gale. Had such a breach occurred previous to the building of the United States dike at High Head, and the State dike at Beach Point, the ocean would have been brought in communication with Provincetown Harbor on the east through East Harbor Creek. This opening once made, aided by the difference in water-level, either side of this outer beach at the various stages of the tide, as ascertained by direct observations, would have increased till the outer part of the cape had been severed from its connection with High Head, and Provincetown Harbor would thus have been destroyed by its exposure to east winds and by the large body of sand which the current would have carried into it through this inlet. To anticipate this catastrophe, the United States dike at High Head was built, which, if the break should occur, (as it actually did in 1874,) would limit the damage to the overflowing of the salt meadow.

UNITED STATES DIKE AT HIGH HEAD.

The construction of the dike will be understood from Plate II, Fig. 2[a] and Fig. 2[b].

The frame-work is a single row of sheet-piling, supported against stringers bolted to 12-inch piles, driven 10 feet apart on the axis of the dike. This sheet-piling was driven to the hard bottom, which was found at an average depth of 8 feet below the surface of the meadow; the piling was cut off 5½ feet above ordinary high-water mark. The length of the sheet-piling is 690 feet.

A wooden sluice was built through this sheet-piling, with its bottom in the level of mean low-water in East Harbor Creek at this point, (4.3 feet below mean high-water,) so that the dike should not interfere with the proper drainage of the salt meadow. This sluice had a gate toward the salt meadow.

The embankment is 17 feet wide on its top, which is 7 feet above mean high-water; the sides are sloped at an angle of 45°, and covered with sodding.

It was completed in 1869. Owing to the decay of the wooden sluice through the dike, a 15-inch cement-pipe, with an iron gate toward the salt meadow, was substituted in 1875.

GROWING OF THE FLATS OUTSIDE BEACH POINT.

The next difficulty to be considered was the observed growing of the flats outside Beach Point, and their encroaching upon the anchorage ground. This was due to the emptying of the large tidal basin of East Harbor inside Beach Point, which received the sand blown from the outer beach into the basin. At every ebb-tide this discharged itself with a velocity large enough to hold the sand in suspense and move it till it met the still water on the edge of the flats, where the sand lodged.

The hydrographic survey of 1873 compared with that of 1835 shows the most marked shoaling to have taken place over the areas marked 1, 2, and 3 on Plate I; the shoaling did not extend beyond the head of Moon Pond Meadow on the east, nor beyond the line, Long Point Light, Mount Ararat, on the west.

The following table exhibits these changes in the interval from 1835 to 1873:

At area marked.	Contour lines of 1835.	Shoaling that has occurred since 1835.	Consequent outward movement of the contour lines since 1835.
	Feet.	*Feet.*	*Feet.*
1	6	0	0
	12	4	250
	18	6	300
	24	3	120
	30	0	0
2	6	0	0
	12	3	150
	18	2½	120
	24	1½	200
	30	1	80
3	6	1	250
	12	4	250
	18	1	100
	24	0	0
	30	0	0

This table shows that the shoaling in a northerly and southerly direction has been limited to the area between the 6-foot and 30-foot contour lines, the maximum shoaling being on the 12-foot curve.

CURRENT OBSERVATIONS PREVIOUS TO CLOSING OF EAST HARBOR.

This result confirms the conclusions, which might have been drawn from the current observations made previous to the closing up of East Harbor. In the depression of

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the flats, designated on Plate I as "Former entrance to East Harbor," the velocity was found on the ebb-tide to be from 2 to 4 miles an hour, while on the edge of the flats no current was observed, or at least none strong enough to hold sand in suspense.

An opinion has prevailed that this growing of the Beach Point flats might be due to the sand carried by wind and tide from Billingsgate Shoal (11 miles to the South) along the Truro shore till it was arrested in the harbor; but a series of simultaneous current observations made in June, 1872, at the stations marked C, C_I, C_{II}, D, D_I, D_{II}, E, E_I, E_{II}, on Plan I, demonstrate that there is no tidal current parallel to the shore strong enough to move sand.

CURRENT OBSERVATIONS SUBSEQUENT TO CLOSING OF EAST HARBOR.

Both surface-currents and subcurrents at various depths were observed at all stages of the tides; but none of the velocities exceeded two-tenths of a mile per hour. The direction of this hardly appreciable movement was perpendicular to the shore; during the flood-tide the movement being toward the shore, and during the ebb-tide off shore.

Whatever material is carried along shore from Billingsgate Shoal in southwest gales is beaten above the low and high water lines by the waves, having the effect to close the mouth of Pamet Harbor and fill the spaces between the jetties on Beach Point; but this effect does not extend below low-water plane. Indeed no perceptible change occurred in the low-water line of the flats between the surveys of 1835 and 1873.

That the shoaling of the flats has ceased with the closing up of East Harbor seems furthermore to be proved by comparing the survey of 1873 with the State commissioners' map of 1867, from which the later survey does not differ materially, although the interval is somewhat short to give conclusive evidence of the cessation of shoaling.

MASSACHUSETTS STATE DIKE.

The State dike, which was built by the State of Massachusetts, was commenced in May, 1868, and completed in June, 1869. The construction of this dike presented more difficulties than either of the other dikes built. The area of East Harbor covered in an extreme tide was about 900 acres; this large body of water flowed in and out through the channel, to be closed up in a little over twelve hours, with a velocity large enough to cut out the bottom, pure sand. The width of the channel was at extreme high water 1,224 feet, and at ordinary low water 930 feet. In narrowing up this channel, and consequently increasing the scouring force of the current, the bottom had to be thus protected that the tide could ebb and flow without scouring up to its final closing. It was first narrowed to a width of 600 feet by embankments built from either shore; the bottom of this new channel was protected from scour by a timber apron 25 feet wide, the flooring being 1 foot above ordinary low water; either side of this apron the bottom was riprapped for a width of 12 feet; four rows of piles supported the apron, which along its edges had sheet-pilings to prevent the water from passing under it. It was planked by abutments and wings of sheet-piling to protect the embankments from wash. A single row of sheet-piling connected the abutment-walls with the shore and formed the supporting frame for the shore-embankment. The 600 feet wide artificial channel was finally closed up by a timber dam, formed of 5-inch thick plank, laid horizontally and tongued and grooved. This timber wall was supported by bracing-frames, 10 feet apart, fastened to the apron. The height of this wall is 9 feet, carrying its top 2½ feet above ordinary high water or above the reach of spring-tides. The construction will be understood from Plate II, Fig. 1[a], Fig. 1[b], and Fig. 1[c], which give a cross-section through the artificial channel, a longitudinal view of the dike, and a plan of the junction of the apron with the shore.

The sheet-pilings were driven from a staging, the construction of which is shown in Fig. 1[a] in dotted lines. It carried a series of railway-tracks for hauling of the sand-filling of the embankment. In the progress of driving the sheet-pilings, previous to putting in the rubble-stone, which would have interfered with the driving of the piles, sand-bags were used to protect the bottom from scour. Their weight was from 75 to 100 pounds, and about 13,000 were used; they proved to be economical and effective.

The embankment was formed with sand from the neighboring hills, and about 150,000 cubic yards was used in its construction. It is 50 feet wide on its top, which is 6½ feet above mean high water. The side towards East Harbor has a slope of 1 vertical to 3 horizontal, while the slope towards the harbor is 1 vertical to 8 horizontal. It is covered with beach-grass and its outer slope protected with brush bulk-head and jetties, as formerly described, (Beach Point.) The Cape Cod Railroad track is laid over this dike.

LONG POINT.

Two batteries had been built on Long Point, one a "three-gun battery" at the extremity of the point, and the other a "five-gun battery," 1,800 feet southwest of the former. The beach between these two batteries was overflowed at extreme high-water, and in order to protect it and increase its height 2,800 running feet of plank bulk-heads and jetties were built in 1866 and 1867. Their location and the details of their construction is shown on Plate III and Plate II, Fig. 5. Further strengthening

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of the extreme end of the beach has been effected by a stone bulk-head built of rough stone, in front of the light-house and the three-gun battery, and extending thence along the beach for a length of 1,000 feet. These works have been effective, and the beach has thereby been so raised that it is now entirely above the highest storm-tide, and is generally covered with beach-grass.

COMPARISON OF LONG POINT, 1835 AND 1873.

Plate III exhibits a comparison between the condition of Long Point in 1873 and 1835, from detailed surveys made at these periods. The map shows a marked growth of the point, especially on the northerly side toward the harbor. To the north of Long Point light the shore, which here is very bold, (falling off into 73 feet of water with a slope of 1 vertical in 3 horizontal, and in places even steeper,) has advanced 300 feet in a northerly direction. One-fourth of a mile inside the point a similar increase has occurred, throwing the contours 200 feet toward the deep water of the harbor. In the former locality, where the survey of 1835 shows 75 feet soundings, the present low-water line runs, showing a shoaling of 75 feet. In the latter it is hardly less marked, the soundings of 39 feet being replaced with 4-feet soundings.

GROWING OF LONG POINT AND HOUSE POINT ISLAND FLATS.

A growth has also been observed in the House Point Island flats between Long Point and Stevens's Point, the survey showing that the steep edge of the flats has advanced 100 feet toward the harbor since 1835.

These encroachments upon the best part of the harbor were ascribed to the sand carried from the outside through Lancey's Harbor and the run between Abel Hill and the opposite beach over House Point Island flats into the deep water of Provincetown Harbor, the process being similar to that which would doubtless have taken place on the Truro shore of the harbor, had the breach at Cove Section occurred previous to the isolation of Salt Meadows and East Harbor basins from the main harbor of Provincetown.

UNITED STATES DIKE AT ABEL HILL.

To stop this movement of sand, the United States dike at Abel Hill was built in the fall of 1871 and the beginning of 1872.

The construction of the dike is illustrated in Fig. 3[a] and Fig. 3[b], on Plate II, which give a cross-section and a longitudinal view of the dike. The main body of sand constituting the embankment is inclosed between two sheet-pilings, 4 inches in thickness and 12 feet apart; these revetments are supported by pile-frames, 8 feet from center to center, each frame consisting of 3 piles driven 7½ feet from center to center; the two outer rows are held together by two stringers, (4½ by 9 inches,) running longitudinally through the whole dike; these stringers served as guides for the sheet-piling. Each 3 and 3 piles are held together crosswise by a 9-inch cap-piece, and cross-braced by two planks bolted to the cap-piece and spiked to the middle pile, resting upon a shoulder and spiked to the sheet-piling, where the lower stringer is. The base of the frame-work is protected by a stone apron. The embankment is 17 feet wide on its top, which is 7 feet above ordinary high water, or 4 feet above the highest tides; the sides are sloped at an angle of 45 degrees, and these, as well as the top, sodded over. After its completion, the foot of the dike was further protected on the northwest side, or toward Lancey's Harbor, with brush, held down by stakes to catch the sand; and on the southeast side or toward House Point Island flats with marsh sods imbedded in the flats. The dike has successfully closed the channel, and cut off the principal supply of material encroaching upon the harbor from the west side; and the growing of the House Point Island flats, and of Long Point, has thereby been checked. If, however, Long Point should continue to grow, and, as supposed by some, ultimately extend across the harbor, and make a lagoon of Provincetown Harbor, it will require an addition to the point of at least 32,000,000 cubic yards of sand before it meets the opposite 30-foot curve; which, estimated at the rate of increase during the last 40 years, would require 1,720 years.

HOUSE-POINT ISLAND FLATS.

A source of shoaling in the westerly part of the harbor still remains in the sand, which is blown from the neighboring hills upon House-Point Island Flats, and thence carried by the ebb-tide toward deep water; the area of the flats covered and uncovered at every tide is 800 acres, of which only 150 acres, or hardly one-fifth, is covered with salt marsh. No doubt an extension of the salt marsh, if practicable, would cause the drifting sand to be retained by the grass, and eventually raise the flats above the reach of the tide.

TRANSPLANTING MARSH.

Experiments have been made in transplanting this marsh. Sods 6 inches square were cut from the marsh near Abel Hill and Stevens s Point, and imbedded in the sand in rows 2 feet apart, the sods being 2 feet apart in each row. A belt from Stevens's Point to House-Point Island, thence to Lobster Point, has thus been covered; also

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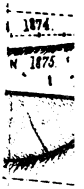

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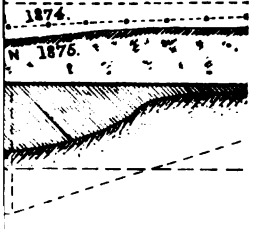

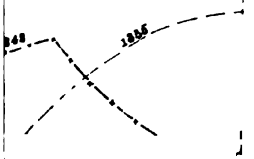

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lines extending across the flats abreast of Gull Hill and southeast of Abel Hill dike. Ten thousand sods have been transplanted, and in most cases promise good results. The trials have as yet been too limited to form a definite idea about their success.

ANNUAL RESURVEYS AT COVE SECTION.

Since 1871 an annual resurvey has been made of the high-water line of the outer beach for a distance of one-half mile either side of Cove Section, as well as levelings across the beach, determining the profiles of this section and of another east of this, called "Oblique Section," a slue-way through the sand-hills. The information obtained is embodied in Plate IV, which exhibits a map of a part of the Salt Meadow, with the outer beach, (Fig. 1,) a profile on the line of the bulk-head, built in 1874 and 1875, showing elevation of the crest between the hills either side of Cove Section (Fig. 2) and the cross-section of the beach at Cove Section, (Fig. 3.) The various stages of the beach are obtained from the following sources of information, viz:

1835, Major Graham's map.

1848 and 1857, United States Coast Survey maps.

1867, Massachusetts State Commission's map.

1871-'72-'73-'74 and '75, United States Engineers' annual resurveys.

The facts proved by these surveys are:

1. That the beach has been wearing away on the outside, and the high-water line has receded at an average rate over the examined mile of coast of 300 feet in the last forty years.

2. That the abrasion outside Cove Section since 1871 has been greater than at any other point examined, culminating, in 1874, in the breach at this place. In the line of mean ocean-level the beach has receded at Cove Section 300 feet from 1835 to 1871, from 1871 to 1874, 200 feet, in addition, making a total encroachment upon this point of 500 feet when the breach occurred. Since the building of the bulk-head and jetties in 1874 and 1875, sand retained in front of and between the jetties has increased the thickness of the beach, within a year, 100 feet.

3. That the sand-hills have receded, the sand from the outside of the dunes blowing over the crest and gathering on the inner side of the hills. The map shows that the present outside high-water line intersects the high-water line of the "Meadow Cove" of 1835, leaving a part of the Salt Meadow washed by the ocean. This fact is further proved by the long black line of marsh-sods now visible in the outside shore-line.

4. Simultaneous with the receding of the crest, a constant lowering of it has taken place, and in no case previous to the breach has there been any increase in height of the crest over that of the previous year. Since 1867 the height of the crest has decreased from Ref. 26.2 feet above mean low-water to Ref. 12 feet in 1874, when the sea broke over it. The crest is now in Ref. 18.4 feet above mean low-water level, owing to the body of sand retained in front of the jetties.

BULK-HEADS AND JETTIES AT COVE SECTION.

The map shows the location of the bulk-head, 607 feet in length, and the six jetties aggregating 126 feet in length. These works were built in 1874 and 1875, and their construction is the same as the Beach Point works, viz, a frame-work of wood filled with brush and ballasted with stone. Previously (in 1873) a bulk-head 205 feet in length, with wings of brush and stakes, was built. It was 133 feet in front of the present and 40 feet in rear of the crest at that time; but the extraordinary gales of November, 1873, and January, 1874, undermined it and necessitated the building of the present one, of which the stability and efficiency have been already tested by violent storms, and which have increased its strength.

PLANTING OF BEACH-GRASS.

In connection with the repair of the beaches by bulk-heads and jetties, beach-grass has been planted for retaining and accumulating the drifting sand. To the successful growth of this plant the permanency of the improvements of the beaches is due in a great measure. Its far-spreading roots check the movement of the sand and give permanency to the surface of the beach, while the tops arrest the sand drifted by the wind. This new accumulation does not check the growth of the grass; on the contrary, the beach-grass keeps pace with it, and sends its shoots above the new layers, thus steadily increasing the sand in height. The results thus far obtained show the planting of beach-grass to be the most economical and effective means of preserving and strengthening the beaches, in completion of that accomplished by the works above described. A watchful and judicious planting of beach-grass where needed will, it is believed, insure the permanency of the good results obtained.

Very respectfully, your obedient servant,

SOPHUS HAAGENSEN,
Assistant Engineer.

Bvt. Brig. Gen. GEO. THOM,
Lieutenant-Colonel of Engineers, U. S. A.

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SURVEY OF BELFAST BAY AND HARBOR, MAINE.

UNITED STATES ENGINEER OFFICE,
Portland, Me., December 9, 1875.

GENERAL: I have the honor to submit the following report on the survey of Belfast Bay and Harbor, Maine. This survey was called for by act of Congress, approved March 3, 1875, "making appropriation for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," and was completed under my instructions in August last by my assistant engineer, Mr. A. C. Both. His report and map of the same, prepared under my supervision, are also herewith submitted.

As the object of this survey was not indicated by the law providing for it, and in the absence of definite information in regard to the improvements most needed and desired for this harbor, I had a careful hydrographic survey made of the whole harbor, from Steel's Ledge up to the bridge, covering an area of about two square miles. This survey includes not only the harbor itself, but also so much of the bay as is necessary for devising a work or works for the protection of the harbor. By this survey the following facts were developed:

1. That the harbor itself is well protected from all winds except those from the southeast; and that to render it safe from these also, would require the construction of a breakwater or breakwaters between McGilvery's ship-yard and Patterson's Point, a distance of about half a mile.

2. That there is a shoal on the west side of the harbor, which extends from McGilvery's ship-yard up to the ledge in front of Lane's wharf, a distance of about five-eighths of a mile. This shoal lies in front of the Boston, Portland and Bangor steamboat-wharves, and in places has but 6 feet of water over it at mean low-water, thereby being a serious obstruction to that part of the harbor.

3. That there is an extensive sunken ledge which projects 160 feet into the harbor in front of Lane's wharf, having over its shoalest part but 3.4 feet of water at mean low-water, or 13.1 feet at ordinary high-water, the mean rise and fall of the tides being 9.7 feet. This ledge is about one-third of a mile below the bridge at the head of the harbor, and, projecting into the harbor, as it does, it necessarily endangers vessels lying or mooring near it.

The locations of the proposed breakwater and of the shoal and ledge above referred to are shown on the accompanying drawing, the area of the shoal being shaded in red, and that of the ledge in brown.

To so improve this harbor as to afford a safe anchorage for shipping in all storms and so that it shall have a suitable depth for the steamers and vessels that touch and lie there, in all stages of the tide, would require the following work to be done, viz:

a. The construction of a riprap stone breakwater or breakwaters between McGilvery's ship-yard and Patterson's Point. The plan now proposed for this work consists in building one breakwater out from McGilvery's wharf in a direction nearly northeast, for a length of 1,500 feet; and a second one out from Patterson's Point (on the easterly side of the harbor) in a direction nearly south-southwest for a distance of 900 feet, thereby leaving an entrance 800 feet in width. By this arrangement the effect of the southeast gales would be very limited in force and extent, and would be felt on the easterly side only of the harbor, which is not used for anchorage-ground. This work would require

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about 200,000 tons of stone, the estimated cost of which (including engineering and other incidental expenses) is $310,000.

b. The excavation, by dredging, of the shoal between McGilvery's ship-yard and the ledge, to a depth of 12 feet at mean low water, which would require about 115,000 cubic yards of dredging, the estimated cost of which (including contingencies) is $25,000.

c. The removal of the sunken ledge in front of Lane's wharf outside of the proposed line, as shown on the accompanying drawing, to a depth of 7 feet, at mean low-water, which would require the removal of about 420 cubic yards of ledge, at an estimated cost (including contingencies) of, say, $12,000. To excavate this ledge to a greater depth, and over a more extended area, would involve a greater expense than would be justified by the benefits gained.

In consideration, also, of the great cost of the breakwaters on the plan proposed, it might be deemed advisable to build only the one extending out from the westerly shore, the estimated cost of which (including engineering and other incidental expenses) is $195,000, but this would give only a partial protection to the harbor; much better, however, than none.

The extent to which the commerce of the country would be promoted by the improvement of this harbor as now proposed, is stated in the accompanying letter from the United States deputy collector of customs of that port.

RECAPITULATION OF ESTIMATES.

For breakwater between McGilvery's ship-yard and Patterson's Point...	$310,000 00
For removal of shoal above ship-yard	25,900 00
For removal of sunken ledge to a depth of 7 feet below mean low-water, say.....	12,000 00
Total.....	347,000 00

Further details and information in regard to the survey and improvement of this harbor, including estimates of cost of same, will be found in the accompanying report of my assistant engineer.

Respectfully submitted.

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. A. C. BOTH, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Me., December 8, 1875.

GENERAL: I have the honor to herewith submit a plan of the survey of Belfast Bay and Harbor, Maine, made in pursuance of your order dated June 15, 1875; the proposed improvements of which are also shown on this plan.

The survey was begun on June 28, continued to July 24, resumed August 18, and completed August 19. The survey was commenced by measuring a base-line of 3,766 feet in length along the west side of the Northport road. This road runs in a southerly direction, is nearly level, and parallel to the shore, and therefore offered great facilities for obtaining a long and accurate base-line. From here the only visible points, the monument and Patterson's Point, were triangulated to serve as a permanent base-line for the survey. The calculated distance between the monument and Patterson's Point was found to be 4,555.68 feet; a drill-hole, half an inch in diameter and one inch deep, cut in the coping-stone at the northwest corner of the monument, indicates the southeast base of this line. The northwest base is located near the high-water line at Patterson's Point, and is indicated also by a drill-hole, one inch deep and half an inch

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diameter, cut into the solid ledge and marked "XII." The triangulation of the principal points shown on this plan was then started from this base-line. The shore-line, wharves, &c., were surveyed by using the telemeter. All these telemeter-stations were conspicuously marked with white paint, with a view to using them afterward as departures for the numerous ranges on which soundings were taken. All the soundings were intersected and located by transit angles. The soundings are expressed in feet and tenths of feet, and refer to mean low-water, the plane of reference adopted for this survey, which is the same as that determined and adopted by the United States Coast Survey. The bench for this plane was transferred from the United States Coast Survey bench to the stone foundation wall of W. Pitcher & Sons' storehouse at the head of Simpson's wharf. It is marked by a horizontal notch and drill-hole, half an inch diameter and one inch deep, cut in a stone of the northeast wall of said building, about 3 feet above the ground and 1½ feet south of the door at the northerly corner. It is marked B. M. 19.67, and its elevation above mean low-water is 19.67 feet. Rise of mean high-water above the plane of reference is 9.7 feet. The extreme northwesterly part of Belfast Bay where the Passagassawakeag River empties into it, forms the harbor of Belfast. The area of this harbor is limited northwardly by the bridge across the Passagassawakeag River, southerly by the proposed breakwater, easterly and westerly by the high-water lines, and contains about 250 acres. About 150 acres of this area is available for the anchorage of vessels of from 6 to 15 feet draught at low-water. The harbor is exposed to the southeasterly winds, ranging from south-southeast to east-by-south, true bearing, but well protected from all others. A channel, of a width of 250 feet and 13 feet depth at mean low-water, runs up in the middle of the harbor as far as Simpson's wharf, from which it turns gradually toward the westerly shore, increasing also in depth up to Frederick's wharf, where there is 24 feet at mean low-water; from here it runs parallel to the shore up to the head of the harbor—the draw-bridge. The approach to the wharves in the upper part of the harbor is thus unobstructed. The lower wharves, viz, Sanford's and Simpson's wharves, the landings of the Boston and Bangor, and the Portland and Bangor steamers, are obstructed by large flats, which project from 300 to 400 feet beyond these wharves. It is proposed to excavate these flats to a depth of 12 feet at mean low-water, and thereby facilitate the movements of these steamers, which arrive here daily and do the largest part of the business of the place. In the present condition of the harbor these steamers are frequently detained several hours at low-water in reaching or leaving the wharves. The excavation of these flats should commence at the westerly side and lower portion of the harbor, and be carried up about 200 feet above Simpson's wharf, a distance of about 2,700 feet. At this point a ledge crops out from the shore and extends up as far as D. Lane's wharf, a distance of about 250 feet. It projects about 160 feet outside of the above-mentioned wharf, and has 3.4 feet of water on its shoalest point at mean low-water. This ledge was generally supposed to be of small extent, but a careful survey of the same developed the fact that it covers a large area, and that it would require for its removal—

	Cubic yards.
To a depth of 12 feet at mean low-water	4,675
To a depth of 9 feet at mean low-water	1,575
To a depth of 8 feet at mean low-water	860
To a depth of 7 feet at mean low-water	420

The great cost involved by the removal of this ledge to a greater depth than 7 feet at mean low-water does not seem to be proportionate to the benefit to be derived therefrom.

It is therefore proposed to remove this ledge to a depth of 7 feet at mean low-water, to the proposed line, limiting the improvements as shown on the accompanying plan. The maneuvering of vessels in that vicinity would thereby be greatly facilitated, and it would to some extent benefit the lower portion of the harbor, by allowing the current at ebb-tides to scour this area, preventing reshoaling. In the present condition of the harbor, exposed as it is to southeasterly blows, vessels have to leave their moorings at the wharves and anchor in the upper part of the harbor, whenever the wind blows fresh from the southeast. The accommodations, however, are limited, and only a small number of vessels can find shelter there. To make the lower, and by far larger portion of the harbor available for safe anchorage during southeast winds, it would be necessary to build breakwaters, as shown on the accompanying plan. These breakwaters are described as follows: Starting from a point of ledge on the Belfast shore, 55 feet north of McGilvery's wharf, it runs in a direction north 42½° east, or nearly northeast, true bearing. Its top, 10 feet wide, is, in reference, 14 feet above mean low-water. It is proposed to build this breakwater of riprap, with an outward slope of 2 feet horizontal to 1 foot vertical, and an inward slope (toward the harbor) of 1 foot horizontal to 1 foot vertical. The length on top will be 1,500 feet. The breakwater proposed from Patterson's Point (△ Station XII) runs in a direction south 18½° west, or nearly south-southwest, true bearing. Its cross-section will be the same as above described, and will

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e 900 feet long on top. In the estimates allowance has been made for a settlement f the breakwaters of 5 feet into the soft bottom. The width of the entrance will be 0 feet. The line through the two heads has a direction south 72½° east, north 72½° st, or nearly east-by-south half-south, true bearing. There is, consequently, but a all exposure to the most dangerous winds southeast. The width of the southeast ave which can enter between the two heads is only 155 feet at high-water, and less low-water, and it rolls into the harbor in such a direction as not to endanger the ty of vessels, the easterly and lower portion of the harbor not being often used as chorage-ground, on account of the hard bottom.

ESTIMATED COST OF IMPROVING THE HARBOR OF BELFAST, ME.

I.—*Dredging.*

e excavation of large flats, extending from McGilvery's ship-yard to Swan & Co.'s wharf, as shown by the red-shaded area on the accompanying plan. to a depth of 12 feet at mean low-water, will require the removal of 115,000 cubic yards of soft mud, as measured in the scows, at 20 cents per cubic yard $23,000
d for contingencies, say 2,000

Total 25,000

II.—*Rock-excavation.*

e improvement of the point of ledge off Lane's wharf, outside of the line limiting the improvements, as shown on the plan, (shaded in brown,) to a depth of 7 feet at mean low-water, will require the removal of 420 cubic yards, at $25 per cubic yard $10,500
d for contingencies, say 1,500

Total 12,000

III.—*Breakwaters.*

a. Breakwater from Belfast shore:
515 tons riprap, at $1.40 per ton $177,121
d for contingencies, say 17,879

Total 195,000

b. Breakwater from Patterson's Point:
865 tons riprap, at $1.40 per ton $104,811
d for contingencies, say 10,189

Total 115,000

RECAPITULATION.

I. For dredging, including contingencies $25,000
II. For rock-excavation, including contingencies 12,000
III. Breakwaters, including contingencies 310,000

Total cost of improvement 347,000

Very respectfully, your obedient servant,

A. C. BOTH,
Assistant Engineer.

Brt. Brig. Gen. GEO. THOM,
Lieutenant-Colonel of Engineers.

COMMERCIAL STATISTICS.

CUSTOM-HOUSE, BELFAST, ME.,
Collector's Office, November 18, 1875.

SIR: I respectfully acknowledge the receipt of your communication of date the 10th instant, in which you inquire—

1st. What amount of revenue was collected at our port during the fiscal year ending June 30, 1875; and

2d. What amount of commerce and navigation will be benefited by the proposed improvements of our harbor.

In reply to the first inquiry I will say that in this collection-district, and mostly at this port, there was collected in duty on imports, for the year ending June 30, 1875,

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$2,294.98. Allow me also to add, in this connection, that our coin collections for the last fiscal year did not come nearly up in amount to what is usually collected in this district in the same period of time. In the year ending June 30, 1873, we collected on import duties, $8,045.86; in the year ending June 30, 1874, $4,827.18; and we have collected since June 30, 1875, $4,130.36.

For answer to your second inquiry, I shall have to depend in a measure upon our men here who are engaged in commerce and navigation, as our official records do not furnish the necessary data, and having consulted them in the matter, it is judged that there have been four hundred and fifty freight-carrying sail-vessels entered our port in the past year, and, as the same number would leave here, and that nearly all, arriving and leaving, are laden with cargoes embracing in the aggregate the various kinds of merchandise, this statement will give you an idea of the extent of our commerce. The steamboat navigation to and from this port consists of four steamers: two Boston steamers coming into this place four times each per week; one Portland steamer touching here six times per week, and a small steamer running daily from here east as far as Brooksville. We have belonging to this district 267 sailing-vessels, 87 of them hailing from this port. There were built in this place in the year ending June 30, 1875, 11 vessels, with an aggregate tonnage amounting to 7,407.33 tons.

Very respectfully, your obedient servant,

MARSHALL DAVIS,
Special Deputy Collector.

General GEO. THOM,
United States Engineer.

A 17.

SURVEY OF HARBOR MATINICUS ISLAND, MAINE.

UNITED STATES ENGINEER OFFICE,
Portland, Me., December 7, 1875.

GENERAL: I have the honor to submit the following report on the survey of the harbor at Matinicus Island, Maine, with an estimate of the cost of the works proposed for its improvement, as shown by the accompanying drawing. This survey, which was called for by the act of Congress approved March 3, 1875, "making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," was made in July last, by my assistant engineer, Mr. Sophus Haagensen, under my instructions; and his report and drawing of same, also prepared under my supervision, are herewith submitted.

When this survey was taken in hand, it was supposed that it was to be made at Ten-Pound Harbor, also known as Matinicus Roads, situated south of Matinicus Island, and between it and Ten-Pound and Ragged Islands, as this was the only harbor that is specially shown and described by the existing reports and charts. But it was ascertained, on a further investigation and examination of the locality, that the survey called for doubtless had reference to the harbor about one mile farther north, on the east side of Matinicus Island, which is frequently resorted to by coasting, fishing, and other vessels. Surveys were consequently made of both of those harbors, and estimates have been made for their improvement by means of breakwaters built as described in Mr. Haagensen's report. On comparing the relative advantages of these harbors, together with the estimated cost of the works requisite to make them effective, as well as the extent to which commerce and navigation would be benefited thereby, it is plainly to be seen that any attempt to improve Ten-Pound Harbor would be impracticable unless attended with an expense that would not be warranted by the benefit that would be derived from it, while Matinicus Harbor, on the east side of the island, offers

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advantages which could be made available at a comparatively small cost, and especially so for fishing, coasting, and other vessels of small class, that would there seek shelter in easterly storms. This harbor is now well sheltered from northerly, westerly, and southerly winds, but only imperfectly so from easterly winds.

The harbor proper, as shown on the accompanying drawing, is partially sheltered from easterly winds by Young's Point, Indian Ledge, Dexter Ledge, and Wheaton's Island, and has an area within the high-water lines of about ten acres, about half of which has from 4 to 8 feet of water at mean low-water. The entrance to this harbor, which is between Dexter Ledge and the island, is not practicable with more than 4 feet at mean low-water, or 13 feet at ordinary high-water, the mean rise and fall of the tide being 9 feet. To give perfect shelter to this harbor would require a breakwater extending from Young's Point, on Matinicus Island, southwardly to Indian Ledge, and thence westwardly over Dexter Ledge to Matinicus Island, leaving open its present entrance between Dexter Ledge and the island.

The estimated cost of a suitable permanent work, as stated in the accompanying report, is $36,000.

Should it, however, be deemed advisable to enlarge the capacity of this harbor, and adapt it to vessels of all classes, it could be effected by building a breakwater from Wheaton's Island northwardly out to Harbor Ledge, (a distance of 1,000 feet,) in connection with one extending from Young's Point to Indian Ledge, which would afford a well-sheltered area of about 38 acres, with good anchorage for vessels of all sizes; but the estimated cost of suitable works is shown in the accompanying report to be $300,000. Such a harbor would doubtless be of very great value in affording refuge to coasting and other vessels caught in easterly gales, especially during severe winters, when the coast harbors are usually closed by ice. But for the local commerce of Matinicus Island, and for the benefit that would inure to such vessels as would usually seek refuge in that harbor, it is not deemed advisable to extend its capacity beyond that of the present harbor proper. In its present imperfectly sheltered condition the value of this harbor may be inferred from the fact, as stated to me by reliable authority, that the harbor is now frequented by vessels and steamers employed in the fishing business from all parts of the Eastern States; that during the past season thirteen steamers entered the harbor at one time, it being not an uncommon occurrence to see from twenty-five to fifty sail of fishing-vessels in there at a time. As this harbor lies directly in the track of the coasting-vessels of Maine and New Brunswick, it would, without doubt, be very much frequented if it could be rendered safe in the manner proposed.

Further details and information in regard to this harbor, with estimates of cost of the works proposed for its improvement, together with a description of the survey, will be found in the accompanying report and map.

Respectfully submitted.

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

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REPORT OF MR. SOPHUS HAAGENSEN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Me., December 4, 1875.

GENERAL: I have the honor to report upon the survey of Matinicus Harbor, Maine, made in pursuance of your instructions of July 16.

Matinicus Harbor is situated on the east side of Matinicus Island, about a mile from the northeast point of the island; it is sheltered from northerly, westerly, and southerly winds, but only imperfectly protected for easterly winds by Wheaton's Island, Indian Ledge, and the ridge of ledge connecting this with Young's Point, Matinicus Island. The harbor proper, where the greater part of the wharves and landings is found, lies north and west of Dexter and Indian Ledges; the area inclosed within these and the main island is about 700 feet by 650 feet within the high-water line, or nearly 10½ acres. About half of this area has from 4 to 8 feet of water over it at mean low-water; the entrance is not practicable with more than 4 feet at mean low-water, *i. e.*, vessels of 13 feet draught may be taken into the harbor on top of an ordinary high water. The entrance is west of Dexter Ledge, between this ledge and Matinicus Island; the soundings seem to indicate a deeper entrance between Dexter and Indian Ledges; but an entrance is impracticable here, as this side (the easterly) of the harbor is obstructed by peaks of ledge cropping out among the bowlders covering the bottom. It is only the westerly side of the harbor which is free from these projecting peaks, having a smooth sand bottom, where vessels may ground without danger of being "hogged." The easterly side of the harbor may be utilized by building piers over the projecting ledges, and this will probably be done when the gap between Indian Ledge and Young's Point is closed up by a suitable breakwater, excluding the heavy easterly sea.

To effectually close up this basin and make it a tidal harbor, where vessels of 13 feet draught may be safe in an easterly gale, it would be necessary to build the following structures, viz: Breakwater No. 1, connecting Young's Point with Indian Ledge; breakwater No. 2, from Indian Ledge over Dexter Ledge to the easterly entrance-pier; and breakwater No. 3, from the westerly entrance-pier to the shore, leaving an entrance 60 feet wide between the termini of breakwaters Nos. 2 and 3.

The following estimates have been made, viz:

Breakwater No. 1.—The site of this breakwater is a ridge of ledge almost in its entire length dry at low-water, while the gap to be closed is upward of 400 feet between the high-water lines of Young's Point and Indian Ledge. It is proposed to build it of riprap, faced on the outside (easterly side) with a large grout, split so as to be laid in courses and doweled together. The top would be a coping-course, 480 feet long, 10 feet wide, in Ref. 15 feet above mean low-water. It would require—

985 cubic yards of large grout laid and doweled together, at a cost of $15 per cubic yard	$14,775
3,000 tons of riprap, at $1.25 per ton	3,750
Contingencies, say	2,875
Cost of breakwater No. 1	21,400

Breakwater No. 2 would be less exposed than No. 1. It is proposed to build it entirely of riprap work, its top 10 feet wide, in Ref. 12 feet above mean low-water; the outside (southerly side) having a slope of 2 horizontal to 1 vertical, the side toward the north having a slope of 1 to 1. The western terminus to be a crib-work pier 20 feet square on top, which would be in Ref. 15 feet above mean low-water. The length of breakwater No. 2, including the terminal pier, would be 420 feet on its top. It is estimated that its construction would require an amount of—

6,020 tons of riprap, at $1.25 per ton	$7,525
The terminal pier, (easterly)	875
Contingencies, say	1,260
Cost of breakwater No. 2	9,660

Breakwater No. 3 would be similar in construction to No. 2. Its length on top, including the terminal pier, would be 175 feet, and require—

2,736 tons of riprap, at $1.25 per ton	$3,420
The terminal pier, (westerly)	875
Contingencies, say	645
Cost of breakwater No. 3	4,940

RECAPITULATION.

Breakwater No. 1, (including contingencies)	$21,400
Breakwater No. 2, (including contingencies)	9,660
Breakwater No. 3, (including contingencies)	4,940
Total cost of harbor	36,000

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The value of the above-described harbor is mainly owing to the deep and partially-sheltered basin inclosed between Indian Ledge, Dexter Ledge, Matinicus Island, and Wheaton's Island, where there is sufficient depth and good holding-ground for vessels of all classes to come to an anchorage; an area of upward of eight acres has from three to five fathoms of water at mean low-water. This basin is used to a great extent by the numerous fishing-vessels always to be found in these waters. The basin might be made a safe harbor, protected from all winds, by the building of a breakwater from Wheaton's Island to "Harbor Ledge," a distance of 1,000 feet.

The direction of this breakwater (marked on the accompanying map "proposed breakwater No. 4") would be north 18° east, or about north-by-east one-half north, true bearing. This breakwater and No. 1 would exclude all heavy sea; the entrance would only be exposed to winds from north-by-east to north-by-west, and the sea caused by those winds is rendered harmless by "No Man's Land" and the ledge around this island. The protected area would be nearly 38 acres. The cost of this breakwater would be great, owing to the depth of water between Harbor Ledge and Wheaton's Island, and its exposed locality. An estimate has been made for a breakwater built of riprap up to the low-water line, where it would have a width of 30 feet, having an outward slope of 2 horizontal to 1 vertical, and an inward slope of 1 to 1. Above low-water it would be constructed as described for breakwater No. 1, only the top of the coping-course would be in Ref. 12 feet above mean low-water. It would require—

3,700 cubic yards of large grout, laid and doweled together, at $15 per cubic yard	$55,500
160,000 tons of riprap, at $1.25 per ton	200,000
Contingencies, say	23,100
Cost of breakwater No. 4	278,600

There are extra facilities for procuring the stone for the proposed breakwaters; the islands are high granite ledges, and all the stone might be quarried in the immediate vicinity and carried on a tramway to the breakwater in process of construction. In case of the building of breakwaters Nos. 4 and 1, the two inner breakwaters, Nos. 2 and 3, might be dispensed with as superfluous. The improvement as proposed would, therefore, be one of the two alternatives:

A. Inclosing the area between Matinicus Island, Indian Ledge, and Dexter Ledge with breakwaters Nos. 1, 2, and 3, so as to make a harbor for small vessels, the entrance being 4 feet at mean low-water and 13 feet at mean high-water, which improvement, it is estimated, would cost $36,000.

B. Making a large harbor for vessels of all classes, at all stages of the tide, by building breakwaters Nos. 4 and 1, which improvement, it is estimated, would cost—

Breakwater No. 1, (including contingencies)	$21,400
Breakwater No. 4, (including contingencies)	278,600
	300,000

The first of these would not have great significance as a harbor of refuge, on account of its only being accessible at high-water; it would benefit the island and the small vessels owned there, which are now in great danger during every easterly storm. The second alternative, B, would be of great importance to navigation; vessels seeking a harbor of refuge during an easterly storm, would not be obliged to run the risk of approaching the rocks and dangers of the shore, but would find a harbor 15 miles from either of the nearest harbors on the shore, Seal Harbor, Tenant's Harbor, and Herring Gut.

The fact that the proposed harbor of refuge at Matinicus Island would be free from ice and accessible at times when the coast of Maine is ice-bound, is, perhaps, the strongest argument in favor of the project. For details of the survey, I would respectfully refer to the accompanying maps, plotted on a scale of 1 to 1200, (100 feet = 1 inch.)

All the stations occupied have been marked by ¼-inch holes, drilled in the ledge for future identification. The soundings are referred to mean low-water, which plane of reference was averaged from five low-waters observed during the survey; the mean rise and fall of the tide during that time was 9.0 feet.

The tide-observations were made on a tide-staff placed on J. Young's wharf, in the southwest corner of the outer harbor. The bench for re-establishment of the plane of reference of the survey is an iron bolt, set in the ledge 25 feet distant from the northeast corner of the wharf; the top of the bolt is in Ref. 12.62 feet above the plane of reference mean low-water.

It was thought the Ten-Pound Harbor, or Matinicus Roads, would offer facilities for the location of a harbor of refuge, and, in accordance with instructions to that effect, a survey was also made at this place. Ten-Pound Harbor is inclosed between Matinicus Island, Ten-Pound Island, and Ragged Island. These islands, however, are not

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sufficient shelter for the inclosed basin, and breakwaters would have to be built to secure a safe anchorage. The most favorable location for a breakwater would be on a line from Curtis Point, on the south side of Matinicus Island, to the northwest point of Ten-Pound Island. The rocky shores of the two islands approach here within 1,650 feet on the high-water lines, and are only 830 feet apart at low-water. The channel between the two islands has 13 feet of water at mean low-water in the deepest place of the line upon which the breakwater could be located. The bottom of this channel is composed of heavy bowlders, with ledge cropping out among them, promising stability to a structure which might be built here. On either side of Curtis Point the shore recedes and forms two coves with good anchorage, a marked similarity to Richmond's Island, Maine, where two coves, similarly situated, have been sheltered by a breakwater between Richmond's Island and the main-land. A breakwater built between Curtis Point and Ten-Pound Island would afford sheltered anchorage during an easterly storm in the cove west of the breakwater between Curtis Point and Cato Ledge, as long as the wind was blowing steadily from the east; but should the wind veer to south or southwest, it would roll the waves into the harbor with unbroken force, and the vessels would be anchored among the breakers, worse off than if they had kept out to sea. The same danger would apply to the anchorage on the east side of the breakwater. The harbor of refuge at Richmond's Island, although "one-sided," has no such drawback, owing to the close proximity of the land southwest of the harbor. A breakwater between Curtis Point and Ten-Pound Island would therefore not be sufficient protection for Matinicus Roads or Ten-Pound Harbor; to make a safe harbor, it would be necessary to build, in addition, a breakwater from Cato Ledge to Ragged Island, a distance of one mile; but the cost of the work would be so much in excess of the cost of the harbor described under B, (nearly four times,) that should a large expenditure be warranted, the preference would be given to the plan of improving Matinicus Harbor by building breakwaters Nos. 1 and 4.

The breakwaters estimated for have the same cross-sections as described for breakwaters Nos. 2 and 3, and would cost for—

A breakwater between Curtis Point and Ten-Pound Island, requiring 50,000 tons of riprap, at a cost of $2.25 per ton	$112,500
A breakwater between Cato Ledge and Ragged Island, requiring 400,000 tons of riprap, at a cost of $2.25 per ton	900,000
Contingencies, say	101,500
	1,114,000

Of the survey in Ten-Pound Harbor, a map has been made on a scale of 1 to 1200.

The plane of reference for the soundings, mean low-water, is 14.16 feet below the bench at Curtis Point—a composition bolt set in the ledge.

Very respectfully, your obedient servant,

SOPHUS HAAGENSEN,
Assistant Engineer.

Bvt. Brig. Gen. GEO. THOM,
Lieutenant-Colonel of Engineers.

A 18.

SURVEY OF IPSWICH RIVER AND HARBOR, MASSACHUSETTS.

UNITED STATES ENGINEER OFFICE,
Portland, Me., December 6, 1875.

GENERAL: I have the honor to present the following report on the survey of Ipswich River and Harbor, Massachusetts, with estimates of cost for its improvement, as called for by the act of Congress approved March 3, 1875, "making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes." This survey was made in June and July, 1875, under my instructions, by my assistant engineer, Mr. Sophus Haagensen; and his report, with accompanying map of the river, from its mouth up to Averell's wharf, at Ipswich, on a scale of 1 to 2000, showing the projected improvements and the estimated cost of same, also prepared under my supervision, is herewith submitted.

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This river is navigable at high-water, from its mouth, where it empties into Plum Island Sound, up to the wharves at Ipswich, a distance of three miles. The entrance to this river is now about one mile southeast of Plum Island, in Ipswich Bay, where vessels can cross the "outer bar" in 6 feet of water at mean low-water. From this bar to the mouth of the river, a distance of two miles, the channel deepens and offers no obstruction to navigation; while between the mouth of the river and Plum Island (in Plum Island Sound) there is anchorage in from three to five fathoms of water. On entering the mouth of the river, between Little Neck and Castle Neck, the inner bar, opposite Lower Gravelly Point, is crossed, where the channel has a width of 60 feet for a depth of 4 feet at mean low-water. The mean rise and fall of the tides is 8.4 feet. From the mouth of the river up to Barras Turns, a distance of two miles, there is an unobstructed channel of not less than 60 feet in width and 4 feet in depth at mean low-water, (or 12½ feet at mean high-water;) but, from Barras Turns up to the Ipswich wharves, the channel is very narrow and tortuous, having in some places not more than 2 feet of water at mean low-water, or about 10½ feet at ordinary high-water. The act of Congress providing for the survey of Ipswich River and Harbor calls for "estimates of cost of dredging the river, so as to give 9 feet depth at mean low-water." This work would require the dredging of the whole length of the river, from its mouth up to the wharves in Ipswich, together with the excavation of a large quantity of ledge, the cost of which, for a channel 60 feet in width, would probably be not less than $300,000; a work which, if its accomplishment should be deemed warranted by the small amount of commerce that would be benefited by it, would prove to be but temporary unless maintained in its full dimensions by constant dredging. But this is not deemed practicable, as, in every easterly storm, the sand outside the mouth would be washed inside, and reproduce, to a greater or less extent, the inner bar near Gravelly Point; while the channel across the outer bar is so variable in depth and locality, that any attempt toward its improvement could not be otherwise than futile. Under these circumstances, I have had prepared a project for the improvement of this river at and above Barras Turns, by which the same depth of the water as below shall be carried up to the wharves at Ipswich, (that is, 4 feet at mean low-water,) for a width of not less than 60 feet, so that vessels of 12 feet draught may be taken up there at ordinary high-water, the greatest depth that it would be practicable to maintain. The details of this project are set forth in the accompanying report of my assistant engineer, to which attention is invited. To effect this improvement would require work to be done at the localities, and at a cost estimated as follows, viz:

1. Opening a new channel across the flats at "Barras Turns," requiring 17,800 cubic yards dredging, at 30 cents per cubic yard	$5,340
2. Riprap stone jetty at "Button Point," requiring 800 tons bowlders, &c., at $1 per ton	800
3. Widening and deepening the channel at "Labor in Vain," requiring 3,500 cubic yards dredging, at 30 cents per cubic yard	1,050
4. Excavation of ledge in midchannel opposite Nabby's Point, 140 cubic yards, at $30 per cubic yard	4,200
5. 3,100 cubic yards dredging on shoal between Nabby's Point and Rogers's Point, at 30 cents per cubic yard	930
6. Removal of Heard's Point Ledge to a depth of 2 feet below the plane of mean low-water, requiring 831 cubic yards of excavation, at $12 per cubic yard	9,972
Adding for contingencies, say	2,708
Total	25,000

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As a bearing upon the facts which show to what extent the commerce of the country would be promoted by the improvement of this river as above projected, I will state that I am informed by the United States collector of customs of this district that "during the fiscal year ending June 30, 1875, there were sixty arrivals of coastwise vessels at Ipswich, with coal, lumber, lime," &c., and that the number would, in his opinion, be increased if the proposed improvements were made in Ipswich River, and much-needed buoys were placed at the bar and in the harbor.

Respectfully submitted.

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. SOPHUS HAAGENSEN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Me., December 1, 1875.

GENERAL: I have the honor to report upon the survey of Ipswich River, Massachusetts, made in pursuance of your instructions of June 12.

A general reconnaissance was made of the river from the head of tide-water in the town of Ipswich to Plumb Island Sound (Lobster Rock Point) previous to the more detailed special surveys.

Upon the existing topographical sheet of the environs of the river (United States Coast Survey chart, 1857, enlarged to a scale of 1 to 2000) were plotted the location of marks established along the river-banks; random soundings, 2,100 in number, were taken in 166 lines, located by the aid of these marks and plotted upon the chart; from this an idea was formed as to which parts of the river were to be more closely examined.

Special surveys were made from Barras Island to Averill's wharf, a distance of one mile, shore-lines were surveyed and the river sounded; the locality of each sounding has been accurately determined, either by instrumental intersections or by a measuring-line; when the latter was used, due allowance was made for the stretch of the line. Numerous borings were made in order to determine the character of the material of the bottom. Where ledge was found soundings were taken at intervals of 5 feet, and the thickness of the covering-materials determined, so as to delineate correctly the ledge contours. Pains have been taken to mark the stations occupied in such a manner that they can afterward be identified; also to establish permanent benches in various localities for the correct re-establishment of the plane of reference, to which the soundings are reduced, and the estimate of work based upon. This plane is the mean low-water averaged from 57 consecutive low-waters, from June 16 to July 15, inclusive; a complete set of tide-observations were taken in this interval, embracing a whole lunation. The tide-staff was placed near the head of the river, on Dodge's wharf, (staff No. 1,) and the result of the observations was as follows, viz:

Mean rise and fall of all tides is	8.4 feet	Above the plane of reference mean low-water.
Highest high-water observed	10.4 feet	
Lowest high-water observed	7.2 feet	
Highest low-water observed	1.8 feet	
Lowest low-water observed	1.3 feet	Below do.

The mean rise and fall determined by the United States Coast Survey in 1852 is 8.6 feet, differing only 0.2 foot from the present value, 8.4 feet.

Near the mouth of the river, on Little Neck wharf, another tide-staff, No. 2, was observed for four consecutive high and low waters, simultaneous with staff No. 1. The rise and fall was found the same at the mouth of the river as at Dodge's wharf, three miles up river; consequently 8.4 added to the sounding on the map will give the corresponding high-water soundings throughout the entire length of the river represented on the map accompanying this report. The following bench-marks were established:

At Little Neck.—A brass bolt set in a large bowlder near the northeast corner of Little Neck wharf; the top of the bolt is in ref. 9.71 feet above mean low-water.

At Jordan's Hill.—A brass bolt set in a large bowlder 12 feet southeast from a lone oak tree; the top of the bolt is in ref. 12.02 feet above mean low-water.

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At Heard's Point.—A brass bolt set in the ledge, 100 feet southwest of the ring-bolt on the highest part of the rock. The reference of the bolt is 9.68 feet above mean low-water. This bolt also marks the south base in the special survey of Heard's Point, while the ring-bolt marks the north base.

The following maps have been prepared:

1. Map showing channel at "Barras Turns," scale ..... 1 to 1000
2. Map showing "Labor in Vain" and "The Shoals," scale ..... 1 to 1000
3. Map of channel round "Heard's Point," scale ..... 1 to 400
4. Map of ledge in the channel at "Labor in Vain," scale ..... 1 to 100
5. Heard's Point, ledge contours, 1 foot equidistance, scale ..... 1 to 100
6. Map of "Outer Bar," at the entrance to Ipswich River, scale ..... 1 to 10000
7. Report drawing, map of Ipswich River from Plum Island Sound to Averill's wharf, showing proposed improvements, scale ..... 1 to 2000

DESCRIPTION OF THE RIVER-CHANNEL.

The entrance to Ipswich River is at present one mile southeast of Plum Island, in Ipswich Bay. There vessels have to cross the "Outer Bar," over which there is 6 feet of water at mean low-water, passing which the channel deepens, and is unobstructed till the mouth of the river is reached. Between this and the south point of Plum Island there is anchorage in 3 to 5 fathoms of water. Leaving the anchorage-ground and entering the river-mouth between "Little Neck" and "Castle Neck," the "Inner Bar" must be crossed off "Lower Gravelly Point." Through this bar there is a channel 60 feet wide and 4 feet deep at mean low-water. From the inner bar there is an unobstructed 4-foot channel, of not less than 60 feet width, running in a meandering course through marshes as far as the beginning of "Barras Turns," which is two miles distant by the river-channel from the inner bar in a direction west-southwest. At this point the navigable 4-foot channel practically ends; and the river-channel must be improved throughout its entire length, from "Barras Turns" to the wharves in Ipswich, in order to make it correspond with the two-mile-long channel below "Barras Turns," *i. e.* to procure a practicable towing-channel 60 feet wide and not less than 4 feet deep at mean low-water, allowing vessels of 12 feet draught to be taken to the wharves in Ipswich on the top of an ordinary high-tide. The special surveys have been made with a view of estimating the amount of work and probable cost of making such a channel. An estimate has also been prepared for a channel 9 feet deep at mean low-water, which was called for by the act of Congress providing for this survey. This work would involve the dredging of the entire length of the river from Plum Island Sound to the wharves in Ipswitch, a distance of three miles, and the excavation of ledges in the upper part of the channel, requiring the removal by dredging

of 200,000 cubic yards of sand-gravel, at 30 cents per cubic yard	$60,000
By submarine blasting of 6,700 cubic yards of ledge, at $30 per cubic yard ...	201,000
Add for contingencies	39,000
Total	300,000

This would be the probable cost of a towing-channel of 60 feet width and 9 feet depth at mean low-water. This channel could not be kept open except by constant dredging, as in every easterly storm the sand from the outside would wash in and reproduce the inner bar off Gravelly Point. The changeable nature of the channel through the sands outside "Castle Neck" is also a strong argument against a deep artificial channel in the river. From an examination of this channel, made July 12, the following facts seemed to be proved:

1. That this channel is now about one-half a mile nearer the south point of Plum Island than it was in 1852.

2. That the bar, which in 1852 crossed the channel of the red buoy No. 4, (see United States Coast Survey chart of Ipswich and Annisquam Harbors, published 1857,) has been advancing, and is now crossing the channel between red buoy No. 2 and black buoy No. 1.

That the bar has not even maintained its relative height; while 7½ feet could be carried over it in 1852, now only 6 feet can be carried, showing a shoaling of 1½ feet. It is, therefore, believed that a 9-foot channel in the river could not be maintained except by constant expensive dredging, entirely disproportionate to the value of such channel for commerce.

In the following, reference will only be made to the continuation of the natural 4-foot channel.

a. At Barras Turns.—Here the channel makes two abrupt turns at right angles, leaving two projecting points of sand-flats, one on each side of the channel; although the points are marked by buoys, vessels generally ground on one of them, owing partly to the abrupt turns and partly to the crosswise current at high-water, when the flats are

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covered. It is not believed that dredging of the points would remedy this difficulty; neither would the improvement be permanent, as the flats would probably resume their present shape after dredging. It is proposed to make a straight cut from the channel outside "Button Point" to the straight portion of the river-channel below "The Turns," and secure the permanency of this new channel by a jetty from Button Point across the old channel, in which a part of the excavated material could be dumped. This work would require the removal of 17,800 cubic yards, mostly sand, at an estimated cost of 30 cents per cubic yard $5,340
And the building of a riprap jetty, 800 tons of bowlders, which may be taken from the adjacent shores at a cost of $1 per ton 800

Total $6,140

b. At Labor in Vain.—The narrow channel between Button Point and Nabby's Point is called "Labor in Vain," probably from the difficulty in navigation. This channel runs at the foot of a 40-foot high wooded bluff, causing baffling winds. For half of its length it is obstructed by a shoal, reducing the depth of the present channel 2 feet at mean low-water. To widen this part of the river-channel to 60 feet, and procure a depth of 4 feet, would require an amount of dredging estimated at 3,500 cubic yards, at 30 cents per cubic yard, $1,050. Opposite Nabby's Point there is a ledge in mid-channel with only 2.4 feet of water over its highest part; the channel is here 7 feet deep above and below the ledge, and several vessels have been "hogged" by grounding on this ledge during the ebb-tide. Its removal to a depth of 7 feet at mean low-water is recommended, which would require the excavation of 140 cubic yards of ledge, at $30 per cubic yard, $4,200.

c. The Shoals.—About midway between Nabby's Point and Rogers's Point there is a shoal consisting of sand, gravel, and bowlders, which only leaves a narrow and crooked 2-foot channel. The red-shaded area shows a location of a 60-foot wide channel, which it is believed can be excavated to a depth of 4 feet at mean low-water, without necessitating any ledge excavation. It would require the removal by dredging of 3,100 cubic yards of sand, gravel, and bowlders, at an estimated cost of 30 cents per cubic yard, $930. The best place to deposit the excavated material is "French's Cove," opposite Nabby's Point; the flats have an elevation of 1.5 feet above mean low-water, or have about 7 feet of water at an ordinary high water. It is estimated that 10,000 cubic yards of material can be easily deposited on the flats opposite "Labor in Vain," as near Nabby's Point as practicable.

d. Heard's Point.—This is a ledge projecting into the river opposite Dodge's wharf, causing an acute bend in the river-channel. It rises almost perpendicularly out of the river from the low-water line to a height of 13 feet above mean low-water, or about 5 feet above high-water mark. The danger in hauling round this point is the close proximity (120 feet at high-water, 100 feet at low-water) of a similar rocky point projecting from the opposite shore, Rogers's Point, and not unfrequently have vessels been caught by the tide and hung up, with bow and stern on the two ledges, across a strong current. To remove the outer end of Heard's Point would greatly relieve the danger of navigating this difficult part of the river. As, however, the channel above Heard's Point rapidly decreases in depth, and none of the wharves above have more than 2 feet of water at mean low-water, the greater part less, it would not be necessary to carry the excavations below the 2-foot grade, *i. e.*, allowing vessels of 10-foot draught to pass this point at high-water. Still this excavation on the proposed line 40 feet back of the high-water line would require the removal of 831 cubic yards of ledge, at a cost of $12 per cubic yard, $9,972.

RECAPITULATION.

To procure a channel 60 feet wide, 4 feet deep at mean low-water, or 12.4 feet at mean high-water, as far as Heard's Point, requires—

Dredging.

A channel at Barras Turns:		
17,800 cubic yards, at 30 cents per cubic yard	$5,340	
Widening and deepening Labor in Vain:		
3,500 cubic yards, at 30 cents per cubic yard	1,050	
A channel through The Shoals:		
3,100 cubic yards, at 30 cents per cubic yard	930	
		$7,320
Building of a jetty at Button Point:		
800 tons of riprap, at $1 per ton		800
Removal of ledge in channel at Labor in Vain:		
140 cubic yards, at $30 per cubic yard		4,200

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Removal of Heard's Point to a depth of 2 feet at mean low-water, or 10.4 feet at mean high-water:

831 cubic yards of ledge, at $12 per cubic yard	$9,972
Contingences, say	2,708
Total	25,000

Very respectfully, your obedient servant,

SOPHUS HAAGENSEN,
Assistant Engineer.

Bvt. Brig. Gen. GEO. THOM,
Lieutenant-Colonel of Engineers.

APPENDIX B.

ANNUAL REPORT OF MAJOR G. K. WARREN, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, R. I., July 19, 1876.

GENERAL: I have the honor to submit the annual reports of improvements and surveys of rivers and harbors under my charge during the fiscal year ending June 30, 1876.

Very respectfully,

G. K. WARREN,
Major of Engineers and Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

B 1.

HYANNIS HARBOR, MASSACHUSETTS.

The amount in my hands for this work at the beginning of the fiscal year was so small that nothing could be done.

The condition and history of this work, and necessity for further appropriation, are fully set forth in my last annual report. (See report of the Chief of Engineers for 1875, Part II, pp. 266–268.)

Hyannis is in the Barnstable collection-district. Barnstable is the nearest port of entry. The amount of revenue collected there in the year ending June 30, 1876, was $——.

Money statement.

Amount available July 1, 1875	$42 94
Amount available July 1, 1876	42 94
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	10,000 00

B 2.

WAREHAM HARBOR, MASSACHUSETTS.

A survey of this work was made under direction of General George Thom, lieutenant-colonel of engineers, in October, 1871, and a report and estimate were submitted by him, dated December 7, 1871. The amount

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of this estimate was $45,000, including $3,000 for the removal of a ledge and bowlder in Weweantic River.

Congress appropriated for this work—

By act approved June 10, 1872	$10,000
By act approved March 3, 1873	10,000
By act approved June 23, 1874	10,000
By act approved March 3, 1875	10,000
Total	40,000

The history of the improvement carried on under the first two appropriations is given in the Annual Report of the Chief of Engineers for 1874, Part II, pp. 216–220; and of it under the appropriation of June 23, 1874, in the annual report of the Chief of Engineers for 1875, Part II, pp. 277–278. Work was commenced on the 6th of June, 1876, under the last appropriation, and up to this time good progress has been made, so that it will probably be completed in July. This appropriation will complete the improvement of the harbor, giving the depth and width to the channel estimated for in report upon survey dated December 7, 1871.

There will then be a channel up to the wharves 9 feet deep at mean low-water, having a width of 100 feet in its narrowest part, and for the greatest part of the distance a width of 200 feet or more. The mean rise of the tide is about 4 feet.

Wareham is a port of delivery. It is in the New Bedford collection-district, and New Bedford is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $9,710.04.

Money statement.

Amount available July 1, 1875	$9,998 95
Amount expended during fiscal year ending June 30, 1876	2,974 17
Amount available July 1, 1876, including $284.83 due on contracts	7,024 78

B 3.

NEW BEDFORD HARBOR, MASSACHUSETTS.

At the date of my last annual report upon this improvement, a contract had been made with the Atlantic Dredging Company of Brooklyn, N. Y., to dredge from near the Fair Haven wharves to the wharves in New Bedford.

Work was commenced under this contract in July, and was completed in October, 1875. A channel 105 feet wide and 15 feet deep at mean low-water (the mean rise of the tide being about 3 feet) was made between the wharves in New Bedford and Fair Haven. (For location of work see maps accompanying the monthly reports.) The amount of material removed was 48,224 cubic yards. The appropriation being nearly exhausted, work was suspended.

The original estimate for the improvement of this harbor was made by me in November, 1874, and was for a channel 200 feet wide and 15 feet deep at mean low-water, from the deep water on the Fair Haven side to the wharves in New Bedford. The estimated cost of dredging and superintendence was $24,000. The price at which the work was done last year was lower than estimated, and probably lower than the remainder will be done for. It is not thought best to reduce the original estimate. It will therefore require the appropriation of $14,000 to

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complete this work, which amount could be expended to advantage in one year.

New Bedford is in the New Bedford collection-district, and is a port of entry. The amount of revenue collected there in the fiscal year ending June 30, 1876, was $9,710.04.

Money statement.

Amount available July 1, 1875	$9,699 49
Amount expended during fiscal year ending June 30, 1876	9,625 62
Amount available July 1, 1876	73 87
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	4,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	4,000 00

B 4.

TAUNTON RIVER, MASSACHUSETTS.

Prior to the beginning of the fiscal year a contract had been duly made with William Flannery, of New York City, for dredging, at 95 cents per cubic yard. Messrs. Staples & Phillips were engaged in July in removing rocks from the channel-way, at $9 per cubic yard. They continued work until November, removing 204.95 cubic yards between Weir and the lower part of the "Needles." From this point down through the "Nook" to Wikamount are occasional bowlders not removed. Below Wikamount the channel is clear of rocks, except at Peter's Point, where a ledge projects into it. This ledge was blasted during last season, but the pieces are not yet removed. Messrs. Staples & Phillips will remove the loose rocks on this ledge during the present month, having put off this work until warm weather so that men could go into the water to chain the rocks. The remainder of the appropriation, if any, will be spent in removing the rocks from the channel-way in the "Nook."

Mr. Flannery removed 3,940.6 cubic yards in making 10 feet at mean high-water through Cobb's Shoal and at Wikamount, and in making 9 feet at the same time of tide through John R.'s Shoal. With the removal of this last shoal we completed the improvement of the upper part of the river on the plan originally made, to make 9 feet at mean high-water.

Since the completion of this channel new shoals have been reported, but it is believed that they have the full depth on them, and are only found in attempting to pass up the river with vessels in advance of high-water.

There remains to be dredged a channel through a clear sand-bar above Berkely Bridge, and the removal of isolated rocks from the "Needles" to Wikamount. It is proposed to do this with the $5,000 asked in the last annual report, if appropriated.

As the work has progressed it has been found necessary to remove a large number of bowlders lying in and near the channel-way, which work was not included in the original estimates.

Owing to the hardness of the material, the prices at which the work has been done have been high. The first dredging was bid for at $1.50 per cubic yard. The contract made at this price was not carried out, because the material was not considered dredgable; this dredging was afterwards let and done at $5 per cubic yard. The next contract was at $3.45 per cubic yard.

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These figures show that any estimate of prices must have been very unreliable.

There has been appropriated for this work—

By act of Congress approved July 11, 1870	$10,000
By act of Congress approved March 3, 1871	10,000
By act of Congress approved June 10, 1872	10,000
By act of Congress approved March 3, 1873	10,000
By act of Congress approved June 23, 1874	10,000
By act of Congress approved March 3, 1875	10,000
Total	60,000

Taunton River is in the Fall River collection-district, and that place is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $6,372.35.

Money statement.

Amount available July 1, 1875	$9,856 84
Amount expended during fiscal year ending June 30, 1876	8,650 94
Amount available July 1, 1876	1,205 90
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	5,000 00

B 5.

FALL RIVER HARBOR, MASSACHUSETTS.

At the beginning of the present fiscal year a contract had been made with Messrs. Curtis, Fobes & Co., of Portland, Me., but no work had been done under it. Work was commenced in November, 1875, and the contract completed in May, 1876. The amount of sand, gravel, mud, and bowlders of less than 2 cubic yards removed was 21,222.19 cubic yards. They also removed 136.53 cubic yards of bowlders larger than 2 cubic yards. We now have a channel 12 feet deep and 100 feet wide at mean low-water. The mean rise of the tide is about 4.7 feet. The original estimate was for a channel 100 feet wide along the wharves and increasing to 300 feet wide at either end. This increased width is in a curved portion of the channel and 12 feet deep at mean low-water.

The contract of last year proved very advantageous to the Government from the fact that the price for dredging all material, including bowlders of less than 2 cubic yards, was but 48 cents per cubic yard; for those larger than 2 cubic yards the price was $10 per yard; but their numbers were few.

This favorable price enabled us to do much more than was estimated could be done for $20,000, the amount thus far appropriated.

To complete the improvement as designed requires the widening of the channel at each end. The material being much softer than in the other parts of the channel, it is probable that it can be done at a less price than that of last year, so that $15,000 will complete the improvement as first designed. This amount can be all expended in one year.

Fall River is in the Fall River collection-district, and is a port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $6,372.25.

Money statement.

Amount available July 1, 1875	$14,386 77
Amount expended during fiscal year ending June 30, 1876	13,789 22
Amount available July 1, 1876	597 55
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	5,000 00

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B 6.

PAWTUCKET (SEEKONK) RIVER, RHODE ISLAND.

At the beginning of the fiscal year dredging was being done on this river, under contract, by Mr. E. R. Seward, of Albany, N. Y. This work was completed last season. The amount of material removed was 31,347 cubic yards. This made the channel in the river to have a least width of 75 feet, (near the wharves it was made 130 feet,) and a depth of 7 feet at mean low-water. The mean rise of the tide is about 4¾ feet. In three places—at Dunnell's, at Bass Rock, and at Swan Point—where the shoals had shown a tendency to form again, the depth was made 9 feet.

In addition to this, a channel was made through the east draw-opening of the new Red bridge, removing therefrom 752 cubic yards of stone, varying in size from a small cobble-stone to stones of one-half ton weight. There is now in this opening 12 feet in the center and 9 feet depth at either side at mean low-water; several piles were also removed from the opening. The stone and piles removed were the remains of an old pile-bridge, the stone having been thrown in to protect the piling.

The history of this improvement up to that date is given in the Annual Report of the Chief of Engineers for 1874, Part II, pp. 229, 230.

The improvement of this river was commenced in 1867, under an appropriation made in that year of	$17,000
By act approved July 11, 1870, there was appropriated	8,000
By act approved March 3, 1871, there was appropriated	7,000
By act approved June 10, 1872, there was appropriated	10,000
By act approved March 3, 1873, there was appropriated	10,000
Making a total of	52,000

No further improvement is now demanded, but, as the shoals in the river are liable to form again, further appropriations for dredging will, in time, be needed, but probably not for several years to come.

A map of this river, from a survey made in 1873, showing the condition of the river at that time from Pawtucket to Providence, with the dredging since done indicated by shading, is forwarded with this report.

Pawtucket River is in the Providence collection-district. Providence is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $182,352.57.

Money statement.

Amount available July 1, 1875	$7,544 83
Amount expended during fiscal year ending June 30, 1876	5,950 22
Amount available July 1, 1876	1,594 61

B 7.

BULKHEAD ROCK, PROVIDENCE RIVER, RHODE ISLAND.

In my last annual report I called attention to the necessity of an appropriation of $5,000 being made for this removal of the rock, so as to give 18 feet at mean low-water.

In 1870 an appropriation of $2,500 was made, and with this the rock was removed down to 14 feet at mean low-water, but this is not suffi-

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cient depth for the vessels passing in and out of Providence River, and it should be increased to 18 feet at mean low-water. The mean rise of the tide is about 4½ feet.

Providence River is in the Providence collection-district, and Providence is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $182,352.57.

Money statement.

Amount available July 1, 1875	$74 98
Amount available July 1, 1876	74 98
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	5,000 00

B 8.

WICKFORD HARBOR, RHODE ISLAND.

At the date of my last annual report, there remained in my hands $1,452.24, applicable to this work. This amount has been expended mainly in widening the channel in the upper part of the harbor (see sketch accompanying monthly report) by dredging.

There is now a depth of about 9 feet at mean low-water, with a mean rise of tide of about 3.7 feet.

The further improvements needed for this harbor are, a beacon on James's Ledge and the removal of the light-house to Old Gay Rock. The importance of these improvements led me to call attention to them in my last annual report, and to annex to it a petition of the citizens of Wickford, and to ask that the same be referred to the Light-House Board.

That the necessity for these improvements was not overestimated was shown by the sinking, last winter, of the steamer Eolus, a vessel plying regularly between Newport and Wickford, and forming part of the route to New York, on James's Ledge.

Wickford is in the Newport collection-district. Newport is the nearest port of entry. The amount of revenue collected there in the fiscal year ending June 30, 1876, was $258.20.

Money statement.

Amount available June 1, 1875	$1,452 24
Amount expended during fiscal year ending June 30, 1876	1,452 24

B 9.

NEWPORT HARBOR, RHODE ISLAND.

The principal work here during the fiscal year ending June 30, 1876, consisted in dredging under an agreement made with William Flannery, of New York. He has removed 58,928 cubic yards of material from the channel-ways. A few bowlders were also taken out.

Work was begun in 1873, with an appropriation of $8,500, made and approved March 3, 1873; it was continued with an appropriation of $10,000, approved June 23, 1874, and with another appropriation of $10,000, approved March 3, 1875; a total of $28,500.

With this sum 113,760 cubic yards have been dredged, several large

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bowlders taken up by a vessel with submarine outfit, hired by the day, and a jetty about 150 feet long built on the south end of Goat Island.

The original project contemplated the removal of 103,500 cubic yards from the channel-ways, and the jetty as now built. This project contemplated removing 26,000 cubic yards between Goat Island and Lime Rock, but only about 11,530 cubic yards were taken from that part because of the hardness of the material at the shoalest part of the main channel-way. Here a cut of about 45 feet width was made, increasing the depth from 12¼ feet to 15 feet at mean low-water. The mean rise of the tide is about 3¾ feet. The sand shoal projecting under water at low-tide from the south end of Goat Island was cut off, and the building of the jetty was done to retard its formation afterward. We have made a channel along the harbor-line north and south, from 85 to 125 feet wide, and from 10 to 12 feet deep at mean low-water; cut a channel from the deep water inward to the harbor-line, about 250 feet wide and 13 feet deep at mean low-water; and another channel nearly east and west from the north end of the harbor-line out to deep water, about 50 feet wide and 12 feet deep at mean low-water. A full history of the work up to 1875 is given in the Annual Report of the Chief of Engineers for that year, Part II, pp. 289–291. A map is sent herewith.

The original project is now essentially completed. A great deal more dredging might be done in increasing the area of deep water, and it would be of benefit to the United States to build a number of short jetties on the west face of Goat Island to protect it from washing by the waves. This is chiefly of importance to the naval torpedo-station located on it, and may be provided for in the appropriations for that station.

Newport is in the Newport collection-district, and is a port of entry. The amount of revenue collected here during the fiscal year ending June 30, 1876, was $258.20.

Money statement.

Amount available July 1, 1875	$11,396 42
Amount expended during fiscal year ending June 30, 1876	10,442 36
Amount available July 1, 1876	954 06

B 10.

BREAKWATER AT BLOCK ISLAND, RHODE ISLAND.

In my annual report for 1874, I stated that the appropriation of $20,000, made by act of Congress approved June 23, 1874, would extend the main breakwater as far as it was desirable, and that the next improvement required was the building of a detached piece, leaving an opening between it and the main work, to protect the harbor from northeast storms.

The length of this pier was proposed to be 300 feet, and it was to be located about 200 feet north of the outer end of the main breakwater, and to run westerly nearly at right angles to the main work. I also stated that—

It is very desirable to have the amount sufficient for this appropriated all at once, for in an incomplete state it would prove a dangerous obstruction.

The amount estimated as necessary to build this detached piece was $60,000; Congress by act approved March 3, 1875, appropriated $20,000. This amount being too small to complete the work, it was deemed best

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to reserve it until Congress should appropriate an amount sufficient to build it before commencing it. This was reported in my annual report for 1875.

The only work done during the last fiscal year has been the putting in of fender-piles around the face of the wharf in the inner harbor, (these piles were placed against and bolted to the piles supporting the wharf,) and such minor repairs as were necessary, and attending to the lighting of the harbor.

The history of this work is given in full in my last annual report. (See Report of the Chief of Engineers for 1875, Part II, p. 249.)

The Board of Engineers appointed to consider and report on breakwater at this place, reported, February 18, 1868, two plans for breakwaters for local purposes: the first to cost $372,000; the second, $553,798.

In the construction of the work the plan reported by this Board has been so modified as to dispense with the cut stone, thereby decreasing the cost so that a breakwater has been built to include as much area as that of the second plan of the Board at an expenditure thus far of $225,000. It should be noted that of this sum about from $50,000 to $60,000 has been expended in dredging and making other facilities for the work, and in removing bowlders from the enclosed area.

The appropriations have been as follows:

By act of Congress approved July 1, 1870	$30,000
By act of Congress approved March 3, 1871	75,000
By act of Congress approved June 10, 1872	50,000
By act of Congress approved March 3, 1873	50,000
By act of Congress approved June 23, 1874	20,000
By act of Congress approved March 3, 1875	20,000
Total	245,000
Estimated as necessary to complete	40,000
Total (estimated) cost when completed	285,000

Block Island is in the Newport collection-district. Newport is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $258.20.

Money statement.

Amount available July 1, 1875	$26,449 53
Amount expended during fiscal year ending June 30, 1876	4,001 83
Amount available July 1, 1876	22,447 70
Amount appropriated by act approved August 14, 1876	40,000 00

B 11.

PAWCATUCK RIVER, RHODE ISLAND AND CONNECTICUT.

At the date of my last annual report, dredging was being done at 28 cents per cubic yard, under contract with T. J. Hill, under the appropriation of $10,000 made by act of Congress approved March 3, 1875. This contract was completed in September, 1875. The whole amount of material removed under it was 22,618 cubic yards. In addition to the dredging, several large bowlders were removed from the channel by days' labor, in the following manner: A hole was drilled in the bowlder to be removed, and a lewis-bolt driven into it. Two scows were fastened together by placing timbers across them, leaving space between them to pass chains over the timbers to the lewis-bolt. The scows were moored

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over the stones at low-water and the chains made fast to the bolt. When the tide rose the stone would be lifted and then floated out of the channel. Whenever the stone was embedded to a greater depth than the rise of tide, as sometimes was the case, the scows were sunk and then made fast, after which they were pumped out. This, with the rise of the tide, usually lifted them clear of the bottom.

The channel was now finished up to Swan's Dock, in Westerly, Rhode Island, 75 feet wide and 5½ feet deep at mean low-water, the mean rise of tide being 2.3 feet. This was as far as it had been contemplated to carry the improvement; the portion above, being occupied for the most part by wharves, was regarded by me as the harbor of the town, and, if improved, the expense should be borne, in part, at least, by the abuttors.

The fact that vessels drawing 7½ feet could reach the lower end of town at high-water, (the head of channel dredged,) while at the same time but 6 feet could be carried above, made the wharf-owners above solicitous that this portion should be dredged. Finally, a proposition was made by them to pay one-half the expense of dredging a channel 45 feet wide and 6 feet deep at mean low-water up to Maxon's wharf, a distance of about 2,400 feet from the upper end of the channel dredged. As there remained unexpended of the last appropriation about $2,700, I recommended that this amount be expended in doing half of the dredging of such channel, as far as it would go. This plan was approved by the Department in letter of October 9, 1875. Work was commenced in November, 1875, and completed in May, 1876; the price paid was 27 cents per cubic yard for all material that the dredge could remove. The amount removed by the dredge was 14,137 cubic yards. Many bowlders were encountered, some of them so large as to require blasting before they could be taken out. Half of the expense of this work was borne by the Government and half by the property-owners. The channel is now completed to the full width of 45 feet in most of its length, and 35 feet in its narrowest part, with 6 feet depth at mean low-water throughout. The improvement of this river is now completed, giving one-half of a foot greater depth, and about one-half mile farther up than was first estimated for. The condition of the river is fully shown on the accompanying map.

The anticipated benefits to the commerce of the place by this improvement are fully realized in the reduction of freights to the extent of from 25 to 75 cents per ton from New York. The value of the improvement will be much further increased by dredging a channel through a shoal in Little Narragansett Bay, into which the river empties, a plan for doing which has already been authorized by Congress, so that vessels arriving there can pass over the shoal at the beginning of flood-tide, and reach Westerly at high-water. It now frequently happens that vessels bound for Westerly get aground in the bay and remain there for a week at a time.

The Pawcatuck River is the dividing-line between the Stonington and Providence collection-districts. Stonington is the nearest port of entry. The amount of revenue collected during the fiscal year ending June 30, 1876, was $1,284 at Stonington, and $182,352.57 at Providence.

Money statement.

Amount available July 1, 1875	$9,793 34
Amount expended during fiscal year ending June 30, 1876	9,616 97
Amount available July 1, 1876	176 37

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B 12.

CONNECTICUT RIVER BELOW HARTFORD, CONNECTICUT, INCLUDING SAYBROOK BAR.

The appropriation of $20,000, made by act of Congress approved March 3, 1875, has been expended in dredging between Hartford and the mouth of the river, and in extending the east jetty at Saybrook Bar in the manner set forth in my last annual report. At that date, July 1, 1876, an agreement had been made with Mr. Goodspeed to do the dredging, he to furnish dredge, scows, and tug, at $75 per day.

The shoals in this river are formed in time of high-water in the river, and although always in the usual neighborhood, it is impossible to tell exactly where and to what extent dredging will be required until the river falls. If we were compelled to advertise at that time for proposals in the usual manner, the large boats running between Hartford and New York would be put to great inconvenience, and perhaps be compelled to make their terminus at Middletown or Saybrook, instead of Hartford. For this reason, authority was given me to hire Mr. Goodspeed to do the work, without advertising, as his price was very moderate.

He removed, during the months of July, August, and September, 13,862 cubic yards of sand from Glastonbury Bar in 46½ days, making a channel 9 feet deep at lowest water through the bar. He also removed 958 cubic yards of sand from Hartford Bar and Pratt's Ferry Bar in 4 days. These three bars, on which the water is nearly always shoal—generally less than 6 feet after every freshet—must be dredged every year, if we are to have a channel of sufficient depth for the vessels running to Hartford.

Surveys of Glastonbury Bar and Pratt's Ferry Bar were made in 1875, prior to the dredging. Maps of these surveys are sent with this report, with the dredging done in 1875 shown on them.

The contractor for furnishing granite for the east jetty at Saybrook Bar finished his contract in October, having put in 8,178 tons, extending the jetty 1,144 feet from the beacon, the initial point.

A temporary beacon was built and placed on the outer end of the west jetty last season. This beacon was knocked down by a vessel in June, 1876.

An examination of the channel between the jetties was made last spring, which showed that there had been little if any change in the depth, except at the outer end of the east jetty, where a small shoal had formed, making it the shoalest place in the channel. When this jetty reaches the full extent designed, the end will meet the strong tidal currents in the Sound, and it is expected that deposits cannot take place.

The monthly reports contain sketches showing the progress and location of the work, so that it is not thought necessary to repeat them here.

Connecticut River, below Hartford, is in the Middletown collection-district; Middletown is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $———.

Money statement.

Amount available July 1, 1875	$19,705 61
Amount expended during fiscal year ending June 30, 1876	19,540 19
Amount available July 1, 1876	165 42
Amount appropriated by act approved August 14, 1876	20,000 00
Amount (estimated) required for completion of existing project	35,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	35,000 00

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B 13.

CONNECTICUT RIVER ABOVE HARTFORD, CONN., AND BELOW HOLYOKE, MASS.

During the fiscal year ending June 30, 1876, the condition of the river has been such as to require no expenditure for improvements. The material obtained from the surveys and measurements in former years has been worked up ready for publication, and all the maps and diagrams prepared for photolithographing. During the progress of the work separate portions of the river and surveys were reported upon by themselves, and these reports have been published in the preceding annual reports. We have, however, combined them all in one report, which it is now desirable to publish by itself, accompanied by the maps and diagrams that generally have not been published.

Some careful measurements on the resistance of cords and floats to currents of water having different velocities (included in this combined report) have not yet been published, and they are therefore given here as an appendix. As there appears little likelihood that the money appropriated for this river above Enfield Falls and below Holyoke can be used in any desirable improvement, I respectfully suggest that the money be partly used in publishing these maps and full report. It will be of much local value as affording exact information of the river and valley, and in the results of its measurements a contribution to river hydraulics and of general interest.

If any shoals should give trouble to the vessels now navigating between Hartford and Enfield Falls this year, the funds on hand are believed to be ample to provide for removing them.

Connecticut River is in the Middletown collection-district. Middletown is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $19,956.14.

Money statement.

Above Hartford and below Enfield Falls.

Amount available July 1, 1875	$12,272 04
Amount available July 1, 1876	12,272 04

Above Enfield Falls, Conn., and below Holyoke, Mass.

Amount available July 1, 1875	$10,702 92
Amount available July 1, 1876	10,702 92

Above Hartford, Conn., and below Holyoke, Mass.

Amount available July 1, 1875	$6,606 65
Amount expended during the fiscal year ending June 30, 1876	2,774 82
Amount available July 1, 1876	3,831 83

REPORT OF GENERAL THEO. G. ELLIS, ASSISTANT ENGINEER.

* * * * * * *

RESISTANCE OF CORDS AND FLOATS.

Some considerable interest having been excited in the question of the resistance of cords and floats when in motion through water, and several experiments having been tried during the progress of the Connecticut River surveys upon the apparatus used for gauging, in order to know what were the actual resistances, such as are deemed of sufficient interest have been added to this report. No reliance was placed upon

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merely mathematical deductions, owing to the insufficient data existing with regard to the friction and resistance of cords and wires when moved laterally through water or other fluids. Experiments were first made upon the longitudinal tension of a cord placed in the current and allowed to sag more or less down stream, with a view to computing the lateral resistance from this element; but direct experiments were afterward made upon the force acting in the direction of the current. The first experiments were made July 20, 1874, at Hartford, between the west abutment and the first pier of the toll-bridge. The cord used was .036 inch in diameter, of hard-twisted cotton, and of uniform size. This was stretched across from the pier to the abutment a distance of 27.2 feet, at a depth of 6 inches below the surface. One end was made fast and the other passed over a brass pulley, so as to measure the tension with a spring-balance. Four experiments were tried, one of which was rejected from an evident error in recording. The others are shown in the following table:

Number of experiment.	Diameter of cord.	Velocity of current.	Greatest versed sine.	Angle at west end.	Tension on cord.
	Inches.	*Feet per second.*	*Feet.*	° ′	*Ounces.*
1	.036	1.51	3.60	30 45	8
2	.036	1.51	3.50	27 30	8½
3	.036	1.51	2.50	24 00	12

The velocity of the current was measured with current-meter No. 2, before described, (see Annual Report of Chief of Engineers for 1875, Part II, pp. 307–8,) at 6.13 and 19 feet from the west bank, giving velocities of 1.35, 1.56, and 1.70 feet per second at those points.

The experiments were continued at the bridge of the Seymour Paper Company, in Windsor Locks, on July 31 and August 1, with the same small cord and with a larger cord of .192 inch diameter. In these experiments the ends of the cords were supported by stakes 9.75 feet apart, and driven into the bed of the canal, so that the current flowed more uniformly and unaffected by the banks between the points of support than was the case in the former experiments. The cords were suspended about 6 inches below the surface, and one end was passed over a pulley as before. The results of these experiments are shown in the following table:

Number of experiments.	Diameter of cord.	Velocity of current.	Greatest versed sine.	Angle at west end.	Tension on cord.
	Inches.	*Feet per second.*	*Feet.*	° ′	*Ounces.*
1	.036	.95	.85	15 10	3
2	.036	.95	.128	30 20	1
3	.036	.95	.125	28 30	1¼
4	.036	.95	.69	19 30	2¼
5	.036	.86	.24	6 15	8¾
6	.036	.86	.50	8 00	4¾
7	.036	.86	.75	21 00	2
8	.036	.86	1.10	30 25	1
9	.036	.86	2.21	.....	½
10	.192	.93	.61	19 00	9½
11	.192	.93	.70	22 30	8
12	.192	.93	.92	29 00	5
13	.192	.93	1.37	36 40	3¾
14	.192	.93	1.97	47 30	2¼

In the foregoing experiments the velocity of the current was measured with current-meter No. 2, before described, at three places across the length of cord, and the mean velocity deduced therefrom. The meter was placed at the same distance below the surface as the cord, and as nearly as practicable under the same conditions; the measurements by the meter occupying some few minutes, while the pressure upon the cord was taken at once. The results of the foregoing experiments not being entirely satisfactory, further experiments were made upon the pressure produced by the direct action of the current upon cords and wires of different sizes, on the 17th and 18th of August, at Hartford.

An apparatus for holding the cord, and measuring the pressure upon it by means of a scale-beam, was constructed, as follows: A frame to hold the cord to be tested was made by extending two stout brass wires downward from a horizontal round wooden axis, and bracing them so as to withstand the tension of the cord stretched between their ends. The distance between these arms to which the cord was attached was 4 feet, and the length of the arms was 25 inches. This frame was hung to a beam by pivots in the ends of the horizontal axis, resting in hook bearings, so as to be easily removed and replaced, and was provided with a horizontal scale-beam having a sliding

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weight like a steelyard. The whole was balanced, and the wire arms hung vertically when the weight was at zero. This apparatus was used by lashing the beam across the gunwales of a boat, so that the frame would hang on one side with the arms immersed about 9 inches. When placed in the proper position for use, the action of the current upon the part of the frame submerged was weighed on the scale-beam. The cord or wire was then attached to the ends of the arms, and the pressure again weighed; the difference in weight gave the pressure upon the cord or wire alone.

In these experiments the velocity of the current was measured with current-meter No. 1, from the boat, in the middle of the length occupied by the frame.

Experiments were made upon both cords and wires of the diameters given in the following tables.

The cords were all hard-twisted, smooth, and of uniform diameter, and were all of cotton, except No. 3, which was a linen fish-line. Most of the cords were stretched tight between the supports, but some were allowed to sag, as noted in the table. The wires were all nearly straight. All of the experiments were made at a depth of 9 inches below the surface of the water.

Table showing experiments upon cords.

Number of experiment.	Number of cord.	Diameter in inches.	Length in feet.	Pressure on frame in ounces.	Total pressure in ounces.	Pressure on cord in ounces.	Velocity in feet per second.	Area square feet	Co-efficient.	Notes.
1	1	.2	4.	2.0	8.3	6.3	2.23	.0667	1.189	Cotton cord, 3″ sag in middle.
2	1	.2	3.92	2.0	8.3	6.3	2.23	.0653	1.214	Cotton cord, 2″ sag in middle.
3	1	.2	3.92	.6	3.0	2.4	1.28	.0653	1.401	Cotton cord, nearly straight.
4	2	.052	4.00	2.0	3.9	1.9	2.31	.0173	1.279	Cotton cord, 1″ sag in middle.
5	2	.052	4.00	0.6	1.1	0.5	1.32	.0173	1.030	Cotton cord, nearly straight.
6	3	.045	4.00	2.0	3.3	1.3	2.27	.0150	1.048	Linen cord, nearly straight.
7	3	.045	4.00	0.6	1.1	0.5	1.36	.0150	1.117	Do.
8	4	.038	4.00	2.0	3.2	1.2	2.23	.0127	1.188	Cotton cord, nearly straight.
9	4	.038	4.00	2.0	3.3	1.3	2.23	.0127	1.284	Cotton cord, 1″ sag in middle.
10	4	.038	4.00	0.6	1.1	0.5	1.33	.0127	1.379	Cotton cord, nearly straight.
11	4	.038	4.00	0.6	1.0	0.4	1.26	.0127	1.238	Cotton cord, 5 feet long. 1′ 3″ sag.
12	5	.036	4.00	2.0	3.2	1.2	2.19	.0120	1.302	Cotton cord, nearly straight.
13	5	.036	4.00	0.6	1.0	0.4	1.29	.0120	1.255	Do.
									1.225	Mean co-efficient.
										The probable error of this mean is ± .021.

Table showing experiments upon wires.

Number of experiment.	Number of wire.	Diameter in inches.	Length in feet.	Pressure on frame in ounces.	Total pressure in ounces.	Pressure on wire in ounces.	Velocity in feet per second.	Area square feet.	Co-efficient.	Notes.
1	1	.075	4.	2.0	4.1	2.1	2.20	.0250	1.082	Copper wire, nearly straight.
2	1	.075	4.	0.6	1.3	0.7	1.19	.0250	1.239	Do.
3	2	.065	4.	2.0	3.8	1.8	2.20	.0217	1.066	Do.
4	2	.065	4.	0.6	1.1	0.5	1.22	.0217	0.965	Do.
5	3	.032	4.	2.0	3.0	1.0	2.19	.0107	1.208	Do.
6	3	.032	4.	0.6	0.8	0.2	1.22	.0107	.821	Do.
7	4	.022	4.	2.0	2.5	0.5	2.18	.0073	.894	Brass wire, nearly straight.
8	4	.022	4.	0.6	0.8	0.2	1.21	.0073	1.126	Do.
9	5	.012	4.	2.0	2.3	0.3	2.15	.0040	1.028	Do.
10	5	.012	4.	0.6	0.7	0.1	1.35	.0040	.824	Do.
									1.025	Mean co-efficient.
										The probable error of this mean is ±.032.

In addition to the foregoing experiments on cords and wires, a few experiments were made on the 29th of August, with the same apparatus, upon the resistance of the floats before described in this report, (see Annual Report of the Chief of Engineers, 1875, Part II, p. 306,) when similarly acted upon by the current. They were attached by

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cords, from 10 to 15 feet long, to the middle of the cord stretched between the arms of the frame, as in the foregoing experiments. The floats were tried alone, and also the whole system together. The resistance of the upper float was obtained by attaching it to the apparatus in the manner described, with a weight of 8 ounces hanging to it at a distance of 18 inches below, and supporting this weight against the current by an independent cord. This was also tried without suspending the weight independently. When both floats were tried together, they were attached independently to the frame, except in one case, when the upper float alone was attached. The center of the lower float was in all cases 18 inches below the surface-float.

An experiment was made upon the lower float alone, suspended at the surface by means of the upper float placed just inside of the top. The velocity of the current was so small at the time of these experiments that it was very difficult to measure the slight resistance of the surface-float. The results would have been more satisfactory with a greater velocity. They are, however, given in the following table, which shows the deductions made from such experiments as were tried. These observations were not originally considered sufficiently complete to be of great value, and, consequently, were not given in the previous report.

Table showing results of experiments upon floats.

Number of experiment.	Shape of float.	Diameter in inches.	Height in inches.	Pressure on float in pounds.	Velocity in feet per second.	Submerged area, square feet.	Co-efficient.	Notes.
1	Ellipsoid.	6.00	1.50	.0136	1.01	.033	.404	Surface float by itself, with 8-ounce weight.
2	Ellipsoid.	6.00	1.50	.0062	.77	.033	.316	Surface float by itself, with 8-ounce weight.
							360	Mean co-efficient. The probable error of this mean is ± .030.
3	Cylinder.	8.47	8.50	.5417	1.28	.500	.662	Sub-float by itself, near the surface.
4	Cylinder.	8.47	8.50	.3124	.91	.500	.755	Sub-float 18 inches below surface-float, both attached.
5	Cylinder.	8.47	8.50	.3176	1.07	.500	.555	Sub-float 18 inches below surface-float, latter only attached.
6	Cylinder.	8.47	8.50	.2719	.87	.500	.719	Sub-float 18 inches below surface-float, both attached.
7	Cylinder.	8.47	8.50	.2541	.86	.500	.687	Sub-float 18 inches below surface-float, both attached.
							.676	Mean co-efficient. The probable error of this mean is ± .023.

In the foregoing tables of the results of experiments upon cords, wires, and floats the last column contains the co-efficients of resistance.

The general formula for the resistance of a body moving in a fluid of unlimited cross-section, is

$$P = C \frac{V^2}{2g} A w$$

In which

P = resistance of the body to motion,
V = velocity,
g = force of gravity at the place,
A = area of cross-section of the body,
w = weight of a unit of volume of the fluid,
C = a co-efficient, supposed to be constant for the same form of solid, but varying for different forms.

As, however, for the same fluid the factor $\frac{w}{2g}$ is constant, both numerator and denominator varying proportionally with the small changes in the value of g, it can be omitted in the computation of the co-efficient C from a series of observations or experiments in the same fluid. The resulting co-efficients are the proper ones for the fluid observed; and if it is desired to apply them to any other, they can be placed in the general formul multiplying by $\frac{2g}{w}$ or making $C = C' \frac{w}{2g}$, C′ being the proper co-efficient for the general formula. Although it is known that the foregoing formula is not exact for a great range of velocity, it is sufficiently accurate to determine the resistance through a considerable range in the values of the area of the cross-section and velocity if the co-efficient is well established by a sufficient number of experiments. It also affords

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an excellent means of comparing experiments at different velocities and with different areas of cross-section, so as to obtain a mean co-efficient. In the foregoing tables the co-efficients which, if applied to the formula, would produce the results of the experiments, have therefore been computed by the formula,

$$C = \frac{P}{Av^2},$$

and the means taken of the results. The pressure P is taken in pounds, the area A in square feet, and the velocity v in feet per second. It will be observed that in the table of experiments with cords the co-efficients are quite uniform, and there appears to be no material difference between the higher and lower velocities, nor between the larger and smaller cords. Neither does there appear to be any difference when the cord has a very considerable curve or sag between the ends. In the series of experiments upon wires a greater difference appears in the co-efficients. This is owing to the fineness and consequent small area of some of the wires, and the slowness of the current, and also to the fact that with the apparatus used the pressure could be taken only to the nearest tenth of an ounce, so that the pressures of 1, 2, and 3 were subjected to a large percentage of error from this cause. As these errors, however, are equally likely to give too large or too small results, the mean is very near the probable truth.

In the experiments upon the small tin ellipsoids used for surface-floats the results are not quite satisfactory, for the same reasons. The two co-efficients given do not, however, vary so much as would be expected from the difficulty of measuring so small a resistance, and the mean may be taken as approximately correct. With the cylinders used for sub-floats the co-efficients are quite uniform, with the exception of No. 5, in which case the floats were attached to the weighing apparatus by a line to the upper float only; so that there is a possibility that the lower float was carried down stream sufficiently to bring the suspending cord against its top edge and cant it slightly. If the result of this experiment is rejected, it makes the mean co-efficient .706, instead of .676, with a probable error of $\pm$ .014.

B 14.

SURVEY OF LITTLE NARRAGANSETT BAY, RHODE ISLAND AND CONNECTICUT.*

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, R. I., November 30, 1875.

GENERAL: I have the honor to present herewith the map of the survey of Little Narragansett Bay, placed under my charge by your instructions dated March 22, 1875, having been authorized by the act for rivers and harbors, approved March 3, 1875. This map is on a scale of 400 feet to the inch, and is made to connect with our former surveys of Pawcatuck River, which flows into it, and the survey of Stonington Harbor, contiguous to this bay on the west side.

A description of the method of conducting the survey and the character of the bay and its environs is given in the report of Assistant Engineer H. A. Bentley, sent herewith. In this report special obstructions to navigation are described, and an estimate of the cost of removing them is given.

This bay is separated from the portion of the ocean known as Block Island Sound by a sand-beach, which has been formed by the ocean waves between Watch Hill and Napatree Point. Both these elevations are of glacial drift, and the latter would be an island but for the connecting beach. The motion of the sand, as washed by the ocean waves, is from Watch Hill toward Napatree Point, and this motion continues on past the point, producing a long sand-spit running north. This has been gradually extending since first surveyed by the United States Coast Survey in 1839. It was resurveyed by them in 1855, the extension in the intervening time having been 1,000 feet, or at the rate of 62½

* Printed as House Ex. Doc. No. 70, 44th Congress, 1st session.

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feet per annum. Since 1855, a period of twenty years, our survey shows a further extension of 650 feet, or 32½ feet per annum. The distance from the point at present to the main channel, in the direction in which the point is now making out, is 1,200 feet, and, with the decreasing rate of progression, it will take a number of years to reach it. When this limit is reached it will become necessary to arrest its further extension by catch-jetties.

Little Narragansett Bay serves as a catch-basin for the littoral sands washed in by the ocean waves, and thus preserves the harbor of Stonington. It has, however, itself become filled up across the middle part so as to afford to vessels no draught greater than 4½ feet at mean low-water. On the south half of this shoal it is sand, brought in and swept around the sand-spit as it advanced; on the northern part it is mud. This latter is necessarily of slow growth, and an adequate channel, once cut through it, would long remain open. This would not be the case with a channel cut through the sandy portions, which would be under the influence of further deposits of sand brought around the sand-spit, and also liable to fill up in the sides from wave-action. We propose, therefore, to cut through the shoal as far away from the sand-spit and as near the opposite shore as practicable. The line selected follows some natural deep places, and has good land-marks by contiguous high points.

This proposed route is at considerable distance from the route ordinarily used, passing near Dennison's rocks, through the middle of the bay and near the sand deposits. It will be more easily improved, will be easier to find and follow in fogs on account of its proximity to the shore, and will avoid the danger of getting on Dennison's rocks. Some rocks, not in the channel that it is proposed to dredge, will need removal, and the expense of this is included. The dredged material can be dumped in the south part of the bay near the beach. The mean rise of the tide is about 2.71 feet. The channel proposed will be 200 feet wide and 7½ feet deep at mean low-water. The whole improvement will cost $51,000, and it is desirable to have at least half this amount to begin the work with, so that the benefit of making an available channel through it of 100 feet width can be had the first year.

This bay is in the collection-districts of Providence and Stonington; the latter is the nearest port of entry.

The revenue collected during the fiscal year ending June 30, 1875, was, at Stonington, $2,376; at Providence, $157,658.34.

The improvement is especially beneficial to the navigation of the Pawcatuck River up to the manufactories and granite quarries at Westerly. The United States have been improving this river the last four years.

Very respectfully,

G. K. WARREN,
Major of Engineers, Brevet Major-General U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. H. A. BENTLEY, ASSISTANT ENGINEER.

ENGINEER'S OFFICE, UNITED STATES ARMY,
Newport, R. I., November 26, 1875.

GENERAL: I have the honor to submit the following report of the survey of Little Narragansett Bay, Rhode Island and Connecticut, made in accordance with verbal directions received from you. This report is divided into three different heads: the first

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is a general description of the country and shores surrounding the bay, and an account of the extension of Napatree Point; the second describes the survey; and the third treats of the proposed improvements.

DESCRIPTION OF SURROUNDING SHORES, &C.

Little Narragansett Bay is at the outlet of Pawcatuck River, and is between Stonington and Watch Hill. It is separated from the ocean by a sand-beach joining Watch Hill and Napatree Point, and another west of the point, the whole about three miles long, leaving an opening between its end and Stonington about one mile wide.

Beginning the description at Stonington Point, which makes out between Stonington Harbor and the bay, and on which the borough of Stonington is located, the extreme point is formed of a deposit of bowlders of various sizes. From here around the bay to the railroad the shore is well covered with bowlders, with some marsh, and, a little farther back, ledge-rock. Along the railroad, to the east side of the Wicketequack River, the shore is of the same general character. Ledwood's Island is at the mouth of the Wicketequack; it is high with rock, both in place and as bowlders, and is connected with the main shore by an embankment and wooden bridge. From the railroad, along the east bank of the Wicketequack, to the point running into the bay, the shore is low and marshy, with a ridge of high land about 300 feet back. Between this ridge and Pawcatuck Point the shore is generally low and swampy, with frequent indentations or little bays of water; this marshy country runs back from the bay nearly three-fourths of a mile. The point at station G, and the one between it and Pawcatuck Point, are about 5 feet higher than the surrounding marsh, and are covered with brush and bowlders.

At Pawcatuck Point the shore forms a gradual slope up from the water-line; it is well covered with bowlders.

With the other shore we will commence the description at Rhodes's Point, across the river from Pawcatuck Point. The shore is well covered with bowlders, with an occasional low, marshy place; this topography continues until we reach Watch Hill, where the land only differs in being a little higher.

Watch Hill Point extends into the ocean about 1,600 feet; it is from 10 to 15 feet high, and is covered with bowlders. Running out from Watch Hill in a westerly direction is the sand-beach, which runs to Napatree Point, before referred to; it varies in height from 8 to 20 feet, attaining its greatest elevation near Watch Hill. It is covered with beach-grass above high-water line. The material of which the beach is formed is, as far as can be seen, sand; except on the ocean-side, where there is, just above high-water line, a narrow strip of gravel. At Napatree Point there is an entirely different formation. A knoll about 25 feet high forms the extreme point; there are bowlders cropping out over the surface; and a section through, that is, as much as can be seen from the steep bank toward the Sound, shows it to be full of rocks. The surface of this knoll is covered with ordinary field-grass; the soil is much richer than that on the beach, and will grow ordinary kitchen vegetables.

This mound, which is about 800 feet long by 400 feet wide, has every appearance of having formerly been an island, to which the beaches were in the course of time joined. It is only at the two probable points of junction that either of the beaches show any signs of breaches. At one (cross-section 4 on map) the ocean, during storms, has been known by the people of the vicinity to break through the beach and maintain a connection with the waters of the bay for several hours. At the other place (cross-section 5) there is every physical evidence of the same thing having occurred, but it is sustained by no witnesses. The "oldest inhabitant" recollects an opening near Watch Hill, (cross-section 1,) through which small boats could pass. The beach at this place, however, shows no evidences of any such break.

Northeast of the knoll, and forming part of Napatree Point, there is a low swampy place, separated from the bay by a low sandy beach. Northerly from Napatree Point, and about at right angles with the first beach, extends the second to Sandy Point Beach. It is much lower than the first beach, at no place being more than 9 feet high. It is about a mile and a half long. There is a pond near the upper end, with 2½ feet of water at the time of survey, June, 1875. The upper end of this beach is known as Sandy Point.

It is constantly extending, as shown by the surveys of 1839, 1856, and 1875. Between 1839 and 1855 it extended 1,000 feet, being at the rate of 62½ feet per year. Between 1855 and 1875 it extended 650 feet, or at the rate of 32½ feet. It probably has a decreasing rate of growth, as the opening between it and the opposite side narrows. There is an exception to this, shown in the form of the beach made between the years 1839 and 1855, where it is of so much less width than that immediately preceding and following it, that it would seem to indicate a rapid growth.

The crest of the bar on the inside, opposite Sandy Point, the upper end of which is known as White Bar, shows an indentation of deep water, which seems to indicate a lack of time in the process of filling up; that is, a rapid growth of the beach was

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followed by a corresponding growth in direction of the bar, and the beach subsequently, when growing more slowly in length but increasing in breadth, was, as may be seen from the map, followed by the bar, leaving the indentation mentioned.

SURVEY.

The survey of the bay was commenced June 11, 1875. It was extended slightly beyond the limits prescribed in the bill ordering it, viz, "from Dennison's Rock to Rhodes's Folly," in order to take in obstructions that the prescribed space would not cover, and also to connect with the surveys of Pawcatuck River and Stonington Harbor, previously made under your direction. The survey, as thus made, gives us, by its connections, a complete map from Westerly to Stonington Harbor, inclusive.

A line was first measured on Sandy Point Beach to serve as a primary base-line of the system of triangulation, with which the area to be surveyed was covered.

The accuracy of the triangulations was tested by a measured base on the other end of the system, the measured distance being only $\frac{83}{100}$ of a foot different from the same line as calculated by using the primary base, and carrying the calculations through the system to this test-base. The triangulations were made with an ordinary transit, and the small difference between the measured and the calculated distance is as near an agreement as could be expected with the instruments used, and for all practical purposes it is just as good as a perfect agreement, the error being a less distance than can be shown by the scale on which the survey is platted. Connections were made by triangulation with the Coast-Survey station at Watch Hill, and with the Stonington and Watch Hill Lights.

On the completion of the triangulations traverse lines were run, or soundings made, as the weather was more favorable for the one than the other. The traverse lines were run around the shores to take the topography, and they were connected with the triangulation stations.

The soundings were located by two instruments measuring angles to them from the ends of known bases. These bases were, as a general thing, the sides of triangles, forming part of the system of triangulation.

Sections of Napatree and Sandy Point beaches were taken at characteristic points by the ordinary method of leveling. The soundings and sections were referred to the mean low-water plane established in 1871, in the survey of Stonington Harbor. A tide-gauge was set up at Watch Hill Landing and read simultaneously with one at Stonington. No regular difference was observed between the rise and fall of the tide at the two places, except in time, high and low water occurring about 30 minutes later at Watch Hill. The rise and fall would sometimes vary $\frac{1}{10}$ foot, but generally it was within $\frac{5}{10}$ foot. The mean rise and fall of tide, according to the observations of 1871, is 2.71 feet. The map of this survey is platted on a scale of 400 feet to the inch. On this map, besides the soundings, topography, &c., are shown the characteristic sections of the beaches. Horizontal scale, 100 feet to the inch; vertical scale, 50 feet to the inch. Also a detached plan of Sandy Point below, same scale as the general map, which shows the different phases of the beach in 1839, 1855, and 1875. The surveys of the first two years were made by the United States Coast Survey.

The triangulation stations are indicated on the map by letters, the traverse station by numbers. A description of the bench-mark established at Watch Hill for a low-water reference will be found on the map. The bench-mark is the highest point of a large bowlder at Watch Hill Landing; it is 12.07 feet above mean low-water. The bench-mark at Stonington described in the report on the survey (see Report Chief of Engineers, 1872, page 919) as the lowest step at the west door of light-house, was found by comparison with other bench-marks given in the same report to be not the lowest step, but the next one above.

The soundings made show a depth of 7½ feet at mean low-water, making in from the Sound for a distance of 1,800 feet above Sandy Point. A corresponding depth also makes down from the mouth of the Pawcatuck to within 1,200 feet of the beach at Napatree Point. These two channels are separated from each other by about 4,500 feet in length of shallow water, of 3½ to 4½ feet deep, covered for the most part with eel-grass. The bottom in the vicinity of White Bar is sand, while along the north shore it is soft mud, with scattering bowlders along the shore-line. A line from Tennison's rocks to the south end of Ledwood's Island is the course of the deepest water across the above-mentioned shoal, and is the course taken by vessels navigating the bay.

IMPROVEMENTS NEEDED.

To connect the deep water on either side of the shoal, and maintain the connection, is the principal improvement sought. The appearance of eel-grass on the shoal indicates that there is no shoaling to be feared from shifting sands, except as the bar inside Sandy Point encroaches. To escape this danger, the proposed channel to be made by dredging was located by you along the north shore of the bay. It united with this advantage that of being close enough to the shore to give good sailing-ranges. The

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cost of making the channel here would be about the same as one made where the present channel is.

The proposed channel is 200 feet wide and 7½ deep at mean low-water.

The interests asking an improvement at this place are the commerce of Westerly, at the head of navigation in the Pawcatuck River, and the steamboat interest of Watch Hill.

The General Government has already improved Pawcatuck River to a draught of 5½ feet at mean low-water, a foot more than can be brought across the bay. The full benefit will not be derived from this completed improvement until a greater depth is made in the bay. A greater draught was made in the Pawcatuck than could be taken across the shoal at its mouth, for the reason that all navigation here is done at high-water, and, when getting through the bay at that stage of tide, the tide in the upper part of the river would be falling before a vessel could reach there.

In the proposed improvements of the bay, the estimates have been made for a draught of 7½ feet at mean low-water; this will allow vessels to come over the bay earlier and give them plenty of time to get to Westerly before the tide turns. It will also allow greater-draught vessels than can get to Westerly to take advantage of the tide and get as far as Lottery before lightering to go above. The lightering is now done at Stonington, four or five miles away by water.

The material along the line of the proposed channel is soft mud and sand, except at Pawcatuck Point, where for a distance of about 300 feet there is a layer of shells over the mud, and with bowlders of various sizes interspersed. The size of the bowlders could not be estimated accurately, as in many instances but a part of the surfaces were above the bottom; a rough estimate would be from 5 to 20 tons.

Besides the making of a channel through the bay, an improvement is needed at Rhodes's Folly. The "Folly" is a heap of small stone placed in the side of the channel, and which formerly served as the foundation of a building put there to evade the liquor-law. The site of the building was supposed at the time it was built to be the dividing-point of the three States, New York, Connecticut, and Rhode Island. The channel at this place is barely 200 feet wide, with a sharp turn in it. The removal of about 75 feet of the "Folly" would very much help the place, and would not be very expensive.

Northeast of the "Folly" are two large rocks, probably bowlders, of about 40 tons each; one is directly in the channel and the other on the edge. There is but 4.50 feet of water at mean low-water at the shoalest places on these rocks, and they are a source of great danger and trouble. An estimate for the removal of these rocks and the improvement of the "Folly" is added further on in this report.

The only other obstruction which was discovered during the survey is a clump of rocks in the cove at Watch Hill Landing. The steamer Massasoit struck on these rocks a few years ago and sunk at the wharf at Watch Hill, with barely time to land several hundred passengers on board at the time. The rocks are small; the largest being probably less than 4 tons, and there are only a few of them. An estimate for their removal is added.

The material dredged during the proposed improvement could all be deposited inside the beach at the deep water near Napatree Point.

ESTIMATE FOR THE ENTIRE IMPROVEMENT.

For a channel across flats, 2,600 feet wide, 7½ feet deep at mean low-water, would require the removal of—	
190,000 cubic yards sand and mud, at 18 cents per cubic yard	$34,200
12,000 cubic yards shells and rocks, at 75 cents per cubic yard	9,000
For dredging at Rhodes's Folly to make an increased width of 75 feet:	
4,000 cubic yards, at 30 cents per cubic yard	1,200
Removal of rocks near "Folly"	700
Removal of rocks at Watch Hill Landing	200
Superintendence and contingencies	5,700
Total	51,000

I was assisted on the survey by Messrs. L. S. Chase and William P. Jewett, assistant engineers.

Respectfully submitted.

H. A. BENTLEY,
Assistant Engineer.

General G. K. WARREN,
Major of Engineers, U. S. A.

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APPENDIX C.

ANNUAL REPORT OF MAJOR J. W. BARLOW, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

ENGINEER OFFICE, UNITED STATES ARMY,
New London, Conn., July 13, 1876.

GENERAL: I have the honor to transmit herewith the reports of river and harbor works in my charge for the fiscal year ending June 30, 1876.

Very respectfully, your obedient servant,

J. W. BARLOW,
Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

C 1.

STONINGTON HARBOR, CONNECTICUT.

At the writing of my last annual report, dredging in Stonington Harbor was in progress under a contract with Mr. Morris F. Brainard, of Albany, N. Y., dated August 26, 1874, and expiring June 30, 1875. By an extension of the time of completion, the contractor was allowed until October 1, 1875, to finish the work. The contract was completed September 23, 1875; 118,422 cubic yards of material having been removed. The depth made was 12 feet at mean low-water, and the area of anchorage-ground of that depth was increased 22.1 acres. In this connection I quote from the report of Mr. G. C. Almy, inspector of the work:

> The favorable effects of the work are already felt, both by vessels seeking temporary shelter and those arriving with freight either for Stonington or Westerly, which is considerably dependent upon the facilities offered by this harbor. All parts of the harbor are more accessible by reason of this improvement, there is more working room for the management of vessels while entering or leaving, they are not crowded so closely when at anchor as to be liable to injury by swinging together, nor exposed to the risk of collision with steamers by encroaching upon the channel leading to the railroad-docks.
>
> As a further means of securing the safety of vessels while in this harbor, it may perhaps be advisable to remove the cluster of rocks on the west side of Wampasset Channel. Their position is at present marked by 2 piles driven some years since for the protection of the steamers of the New York and Stonington line, which at that time habitually used that channel, but these piles are at most only temporary safeguards, and as no one is specially responsible for their maintenance they will soon decay and disappear.
>
> There is from 4 to 6 feet of water over the rocks at low-tide. The cost of their removal would be slight compared with the damage they are liable to cause.

For the past year an appropriation of $25,000 was made by act of Congress approved March 3, 1875.

A Board of Engineers was convened to decide upon the most expedient plan for making a harbor of refuge at this place; they reported three projects, giving preference to the first, which was adopted. The total amount estimated for the completion of this project was $231,536, of which $213,536 was for the construction of a breakwater running southeasterly 283 yards across Wampasset Shoal, thence easterly 400 yards. The other $18,000 was estimated for dredging.

Before the convening of the Board of Engineers, specifications for a

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breakwater on the south end of Penguin Shoal had been issued in accordance with a project previously approved.

On the 22d of June, a week before the session of the Board, proposals were opened. In view of a possible change in the location of the work an opportunity was then afforded each contractor to withdraw his bid, although the conditions as regards depth of water, exposure, &c., were practically the same on Wampasset as on Penguin Shoal. No bids were withdrawn, and the lowest was presented by Mr. J. Schuyler Crosby, of New York, being $1.45 per ton. Mr. Crosby consented to do the work in the manner prescribed by the report of the Board of Engineers, and a contract with him was drawn up August 1, 1875, to expire July 1, 1876. Work under this contract was begun August 17, 1875, on the northwest end of the breakwater, in water averaging about 3.5 feet depth. With the approval of the Chief of Engineers, U. S. A., the coping provided for in the project was omitted from this year's work.

The breakwater was continued for a length of 770 feet, ending in water of 15 feet depth.

The total amount of stone delivered was 14,507 tons, and the contract was completed May 23, 1876.

There yet remain of the approved project 53,618 cubic yards of riprap to be put in, at an estimated cost of $3 per yard.

The work of the past year was done much below the estimated figures; and equally low, or possibly lower, rates could be secured again if the appropriation were large enough to invite competition.

Fifty thousand dollars could be expended to advantage for the year ending June 30, 1878.

Stonington Harbor is in the Stonington collection-district; the amount of revenue collected there during the fiscal year ending June 30, 1876, was $1,283.68.

In a report dated December 18, 1871, accompanied with a map of survey, Major Warren submitted estimates chiefly with a view to construction of a breakwater from Stonington Point and a sea-wall from Wampasset Point. The first appropriation made after this report was specified as "for dredging in Stonington Harbor," and was applied to making a depth of 12 feet between the old breakwater and the steamboat-dock. The next appropriation was applied to the removal of the upper end of Penguin Shoal, and was exhausted in September, 1875. The last appropriation was expended as described in this report, in accordance with the project of a Board of Engineers convened in June, 1875, to devise a plan of permanent improvement. The result of the work of the two previous years was utilized in this project as part of the increased anchorage-ground provided for.

Following is a list of the several appropriations since the report on the survey of 1871:

March 3, 1873.—Dredging between old breakwater and steamboat dock	$25,000
June 23, 1874.—Dredging on Penguin Shoal	20,000
March 3, 1875.—Commencement of breakwater at Wampasset Shoal	25,000

Money statement.

Amount available July 1, 1875	$37,489 52
Amount expended during fiscal year ending June 30, 1876	36,529 77
Amount available July 1, 1876	959 75
Amount (estimated) required for completion of existing project	206,536 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	50,000 00

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C 2.

NEW HAVEN HARBOR, CONNECTICUT.

By act of Congress, approved March 3, 1875, $10,000 was appropriated for the improvement of New Haven Harbor.

Advertisements were made inviting proposals for widening the channel between Long wharf and Belle dock. Bids were opened June 22, 1875, and the contract awarded to Mr. Emory R. Seward, of Albany, N. Y., he being the lowest bidder.

Work was commenced March 23, 1876, with one dredge, of the Osgood pattern. June 19 a second dredge arrived, but has been hindered in her work by want of scows. At the close of the fiscal year, 43,606 cubic yards of sand and mud have been removed from the channel, making it 315 feet wide and 13 feet deep at mean low-water.

The contract is now about one-half performed; its completion will give a width in the 13-foot channel of 400 feet.

The price for the work being very low, a recommendation that the contract be extended three months was approved, and the work is still in progress.

In a letter dated January 27, 1875, and printed in Appendix Z of the annual report of the Chief of Engineers for 1875, estimates were submitted for widening and deepening the main channel, and for a breakwater near the entrance to the harbor. To these I would respectfully refer, renewing my recommendation therein contained.

New Haven is the port of entry of the collection-district of New Haven. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $385,116.64.

Since the last project was submitted and approved, January 27, 1875, the only appropriation made was the one of act approved March 3, 1875. Its expenditure is described in this report.

The following amounts have been appropriated and expended since 1866:

July 11, 1870.—Work on Middle Rock, and beginning at 13-foot channel, 200 feet wide from Fort Hale to Long wharf, and 100 feet wide to Belle dock	$15,000 00
March 3, 1871.—Completing the above channel and working on Ludington Rock	40,000 00
June 10, 1872.—Beginning channel 200 feet wide, 16 feet deep, from Fort Hale to light-house	20,000 00
Removal of Ludington Rock	15,000 00
March 3, 1873.—Completing channel from Fort Hale to light-house, and widening channel from Long wharf to Belle dock	25,000 00
March 3, 1875.—Widening to 400 feet channel from Long wharf to Belle dock	10,000 00

LUDDINGTON ROCK.

Accompanying my letter of January 11, 1876, was transmitted a map of a survey of the rock, made in August, 1875, and showing that 294 cubic yards of sand, loose stone, and rock yet remain to be removed before the required depth is fully attained. This the contractor has repeatedly expressed his intention of removing. He has been delayed during the spring by other works, but now promised to begin operations during the month of July. No work has been done on the rock, and its condition is the same as at the time of my last report; its location is now marked by a can-buoy.

No appropriation is required for next fiscal year.

Money statement.

Amount available July 1, 1875	$16,237 29
Amount expended during the fiscal year ending June 30, 1876	4,539 95
Amount available July 1, 1876, including $2,495.21 due on contracts	11,697 34

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C 3.

MILFORD HARBOR, CONNECTICUT.

A contract was entered into on the 3d of August, 1875, with Mr. Sidney F. Shelbourne, of New London, Conn., to dredge a channel 100 feet wide and 4 feet deep at mean low-water across the bar at the upper end of the harbor, to a point opposite Mr. W. M. Merwin's dock. For this purpose $6,000 was set apart from the appropriation of $13,000, the remainder being applied to the construction of jetties. The contractor removed 622 cubic yards in October, and then delayed further operations until the 30th of March, 1876. The total amount removed to the close of the fiscal year was 18,799 cubic yards, being a little over one-half of the contract.

A two-months' extension of the contract has been granted, and work is still in progress.

The small jetties that were built along the shore to retain the drifting sand and gravel worked so effectually, that the accumulated materlai threatened to raise the level of the beach above that of the jetties, and it was found necessary to build the shore ends higher; this was done in August, 1875, adding a height of 3 feet at high-water mark.

By a violent storm on February 14, 1876, some of these jetties were injured; the damage was not great; they were repaired at small expense, and the bases widened so as to be more substantial than before.

On the 1st of September the construction of the long jetty at the mouth of Indian River was begun, work being done by day's labor, and material being obtained from the vicinity. This jetty will be completed during the month of July. It is 550 feet long, 6 feet wide on top, and from 16 to 18 feet wide at the base, and 10½ feet high. It contains (June 30, 1876) 3,698 tons of stone, with about 300 tons yet required to finish it. The completion of this jetty and of the channel now being dredged will complete the plan as originally designed for improving the upper harbor.

The extent of the channel to be made under the present contract is such as to be of benefit to parties owning docks at the mouth of the Wepanwog River, but its use to the town in general would be greatly augmented by carrying the channel up to the town docks an additional length of about one-half mile, involving the removal of 45,000 cubic yards of mud, at 20 cents per yard, $9,000.

If it appears advisable to commence the construction of a breakwater at Welch's Point, with a view to creating a harbor of refuge at this place, $55,000 could be expended to advantage during the year ending June 30, 1878. The reasons for advocating this scheme were considered in my last annual report, and still exist.

Milford is in the New Haven collection district, New Haven being the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $385,116.64.

June 23, 1874, $5,000 was appropriated for improving Milford Harbor, and was expended in building jetties along the eastern shore. March 3, 1875, $13,000 was appropriated and has been expended as stated in this report. This is all the work ever done by the General Government in improving the harbor of Milford, Conn.

Money statement.

Amount available July 1, 1875	$13,059 11
Amount expended during fiscal year ending June 30, 1876	8,352 46
Amount available July 1, 1876, including $1,399.95 due on contracts	4,706 65
Amount (estimated) required for completion of existing project	64,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	64,000 00

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C 4.

HOUSATONIC RIVER, CONNECTICUT.

At the date of my last annual report work was in progress at Crofut's Bar, making the channel 80 feet wide and 7 feet deep at mean low water. After completion of this work it was found necessary to dredge on the shoal that forms below Drew's Rock jetty, and during July, 1875, 1,636 cubic yards were removed. This shoal has now been dredged off 4 times, and in the event of its forming again, I propose to cut through it, so that the cut shall strike the main channel at some distance below the jetty, avoiding the abrupt turn of the present channel and probably destroying much of the bad effect of the current, which now forms an eddy below Drew's Rock, and stirs up the material which creates the shoal. Each new formation of the shoal seems to occur at a slower rate than the preceding one, and since last July it has not increased sufficiently to become a serious obstacle.

An examination made early in June showed no remarkable changes since last year. The worst feature was the shoaling of what was known as Drew's Bar, about 500 feet above Drew's Rock, and a dredge was immediately placed at work there. At the point where the channel crosses the river, just below Sow and Pigs Rock, and one-half mile below Derby, there has been some filling; this will be excavated. It seems probable also that Mill Bar will require some work. On the whole the effects of the winter have not been as damaging as might have been expected. I have prepared and transmit herewith a map of the whole river from Huntington bridge, the extreme head of navigation, to Long Island Sound, on a scale of 1,000 feet to the inch. The contours show the locations of all the shoals, and it will be observed that with the exception of the one above Drew's Rock, they all occur at or immediately below places where the channel crosses from one bank to the other. It is a fact worthy of note, that, without exception, the channel lies on the side of the river where the shore is steepest, and the depth of the channel seems to vary approximately with the ratio of the steepness of the sides.

Work on this river has been done by a dredge, and apparatus hired by the day.

I recommend an appropriation of $5,000 for the purpose of keeping the depth of 7 feet secure against the action of freshets. A small appropriation every year will keep this river in very navigable condition.

Housatonic River is the dividing-line between New Haven and Fairfield counties. Bridgeport is the nearest port of entry, where the revenue collected during the past fiscal year was 4,302.33.

The following appropriations have been made for improvements on this river:

March 3, 1871	$15,000
June 10, 1872	15,000
March 3, 1873	10,000
June 23, 1874	10,000
March 3, 1875	5,000
Total	55,000

The wing-dam at Sow and Pigs Rock was built in 1871; that at Drew's Rock in 1872; the rest of the money has been expended in dredging at various times at Huntington Landing, Two Mile Island,

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Crofut's Bar, Drew's Bar, below Drew's Rock, Mill Bar, and, in 1873, in removing a cluster of small stones and shells known as "The ballast."

Money statement.

Amount available July 1, 1875	$8,950 05
Amount expended during fiscal year ending June 30, 1876	4,489 94
Amount available July 1, 1876	4,460 11
Amount that can be profitably expended in fiscal year ending June 30, 1878	10,000 00

C 5.

BRIDGEPORT HARBOR, CONNECTICUT.

The appropriation of $15,000 by act approved March 3, 1875, was expended in making a channel 100 feet wide, and 12 feet deep at mean low-water. The contract for this work was completed in December, 1875. This depth will prove sufficient for the wants of the city for some time to come, but in order to make it of practical use, the channel should be made at least 300 feet wide, and with this object in view I recommend that $25,000 be asked for for the next fiscal year. The total amount necessary for the completion of such a channel is $46,000. Estimates are given in detail in the report of Mr. W. W. Starr, jr., assistant engineer, which is transmitted herewith.

During the coming autumn, should any funds be available, I shall make a careful examination of the harbor to determine what has been the effect of the jetty, and to ascertain whether it is desirable to carry it out into deeper water.

Bridgeport is the port of entry of the Fairfield collection-district. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $4,302.33.

In a letter of January 12, 1871, a plan was submitted with estimates for a line of dolphins, extending 2,600 feet from shore, with a jetty between high and low water marks; also for dredging a channel 14 feet deep and 200 feet wide, the total estimated cost being $196,000. Subsequently it was decided to substitute for the line of dolphins a riprap jetty, which in 1872 and 1873 was carried out a length of 1,380 feet. Further work on the jetty was then suspended on account of the imperative need of an increased depth and width of channel. By reason of the large cost of dredging to 14 feet depth, it seemed advisable to make the channel at first 9 feet deep, so as to afford an immediate relief to the growing commerce of the city, and part of the appropriation made in 1872 with those of 1873 and 1874 were devoted to dredging a 9-foot channel of a width nowhere less than 300 feet.

The appropriation of 1875 was expended, as stated in this report, in making a 12-foot channel 100 feet wide.

Following is a statement of the amounts appropriated for Bridgeport Harbor:

March 3, 1871	$20,000
June 10, 1872	40,000
March 3, 1873	30,000
June 23, 1874	20,000
March 3, 1875	15,000
Total	125,000

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Money statement.

Amount available July 1, 1875	$22,817 09
Amount expended during fiscal year ending June 30, 1876	22,762 24
Amount available July 1, 1876	54 85
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	25,000 00

REPORT OF MR. W. W. STARR, JR., ASSISTANT ENGINEER.

NEW HAVEN, CONN., *July* 1, 1876.

COLONEL: I have the honor to submit the following report for the year ending June 30, 1876, on the improvement of Bridgeport Harbor, Connecticut.

At the close of the last fiscal year, (ending June 30, 1875,) the contract for dredging, dated September 16, 1874, with Mr. E. R. Seward, of Albany, N. Y., had not been completed. During the first month of the year just closed, sufficient material was removed to exhaust the appropriation under which the work was done and to complete the contract. The amount removed under that contract after June 30, 1875, was 18,672 cubic yards, as follows: 11,677 cubic yards of sand from the east side of the outer bar, 97 cubic yards of sand from the inner bar, and 6,898 cubic yards of mud from the west side of the channel above the inner beacon, making the depth at least 9 feet at mean low water.

Under the appropriation of March 3, 1875, ($15,000,) you entered into a contract with Mr. E. R. Seward, of Albany, N. Y., to dredge a channel 100 feet wide and 12 feet deep at mean low-water, from the 12-foot curve outside the light-house to the docks, he being the lowest bidder when the proposals were opened. The prices were as follows: for the outer bar, 16 cents per cubic yard; for the inner bar, 15 cents per cubic yard, and above the inner beacon, 10 cents per cubic yard.

Work was commenced July 27 and completed December 24, 1875, three dredges of the Osgood pattern being at work during most of the time. The whole amount of material removed was 100,264 cubic yards, as follows: 34,913 cubic yards from the outer bar, 17,694 cubic yards from the inner bar, and 47,657 cubic yards from above the inner beacon, making a channel 105 to 110 feet wide and 12 feet deep at mean low water.

The following estimates for continuing the work of improvement in this harbor are respectfully submitted. They are the estimates of last year, with such changes only as are made necessary by the work since done.

For a channel 12 feet deep, 200 feet wide:

49,305	cubic yards of sand, at 20 cents	$9,861 00
101,042	cubic yards of mud, at 15 cents	15,156 30
150,347	cubic yards	25,017 30

Three hundred feet wide:

102,314	cubic yards of sand, at 20 cents	$20,462 80
168,634	cubic yards of mud, at 15 cents	25,295 10
270,948	cubic yards	45,757 90

In the foregoing estimates no allowance was made for superstructure, office expenses, &c.

The breakwater should have a few repairs in the shape of some heavy stones at the head; some that were dislodged from the top of the wall by the heavy ice of the winter of 1874–'75, should be replaced. The whole cost would not amount, probably, to more than $350.

Before further work is done in the harbor, I would respectfully recommend that a thorough examination be made of the channel, with a view to determining what action the breakwater and the currents of ebb and flood have upon the same, and whether the channel is filling or not.

Respectfully submitted.

WM. W. STARR, JR.,
Assistant Engineer.

Col. J. W. BARLOW,
Corps of Engineers, U. S. A.

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C 6.

SOUTHPORT HARBOR, CONNECTICUT.

With the appropriation of $5,000 made by act approved March 3, 1875, a coping 2 feet thick and 5 feet wide was placed upon the whole length of the breakwater, except a short distance above high-water mark, where its place was supplied by a fence of yellow pine 2½ feet high and 135 feet long. In order to attain a uniform slope for the whole wall it was found necessary to raise the level in some places with rubble-stone. Rubble had also to be used in places to make a good bed for the coping; 183.7 cubic yards of rubble were used for these purposes. The report of Mr. F. N. Lincoln, inspector of the work, is transmitted herewith.

In connection with this improvement, I had a survey of Southport Harbor made, a map and report on which, by Mr. Wm. W. Starr, jr., assistant engineer, accompany this report.

From Mr. Starr's estimates it will be seen that to dredge a channel 4 feet deep will cost about $8,000. There is but a small tidal basin above Southport Harbor, and no appreciable effect could be expected from scouring. Such a channel, exposed as it would be to the full force of the waves of Long Island Sound, would require, to keep it permanent, a jetty on the east side, the cost of which could not be less than $50,000. The necessary repairs of the dike are small, and can probably be accomplished from the remainder of last year's appropriation.

Southport Harbor is in the Fairfield collection-district, of which Bridgeport is the port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $4,302.33.

The only appropriation made for improving Southport Harbor since the completion of the breakwater in 1838 was that of $5,000 made by act approved March 3, 1875, and expended as described in this report.

Money statement.

Amount available July 1, 1875	$5,000 0
Amount expended during fiscal year ending June 30, 1876	4,616 0
Amount available July 1, 1876	383 9
Amount appropriated by act approved August 14, 1876	5,000 00

REPORT OF MR. F. N. LINCOLN, INSPECTOR.

ENGINEER OFFICE, U. S. ARMY,
New London, Conn., June 30, 1876.

COLONEL: In accordance with instructions from you, I proceeded to Southport, Conn August 24, 1875, to take charge of the repairs on the breakwater at that place. The work was to consist of a coping 2 feet thick over the old breakwater, which was built about forty years ago and was badly shattered on top by the action of the sea.

This coping, for which the contractors, Messrs. Beattie & Dresser, were then delivering stone, was to be laid 2 feet thick and 5 feet wide, of single stones laid as headers and brought to a 3-inch joint. September 4, the working party arrived and commenced placing the stones in position on the wall. This work, starting from a point about one-quarter of the distance from the shore end, was prosecuted in both directions, as the stage of the tide would permit, until its completion January 8, 1876. The work progressed slowly, for two reasons: principally because the stone furnished, although of satisfactory size and quality, was so roughly quarried that much time was necessarily expended in working it down to the desired joints; and secondarily, because there were several places in which the old wall had to be rebuilt to secure a good foundation.

For a length of 853 feet, the new coping was laid on top of the old wall after simply

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bringing the latter to an even surface. For the remaining 183 feet at the shore end of the work, the old breakwater was raised 0.5 foot before placing the coping. This was done to catch the sand which the southeast storms roll along the beach, and more effectually prevent its rolling over the breakwater into the channel.

As a guard against the sand which sometimes in severe blows rolls over the old work at a point where coping was not deemed necessary, a fence 2½ feet high, of 2-inch southern-pine plank, securely spiked to chestnut posts 7 inches square, sunk 4½ feet into the ground at intervals of 7½ feet, was built in the line of breakwater for a length of 135 feet from its shore end, the top of the fence being on a level with the top of the shore end of the coping.

In addition to 386.6 cubic yards of coping used over a length of 1,036 feet, 183.7 cubic yards of rubble-stone were used in filling gaps in the old wall and in bringing it to a proper level to receive the coping.

Very respectfully, your obedient servant,

F. N. LINCOLN.

Col. J. W. BARLOW,
Corps of Engineers, U. S. A.

REPORT OF MR. W. W. STARR, JR., ASSISTANT ENGINEER.

BRIDGEPORT, CONN., *March* 15, 1876.

COLONEL: I have the honor to submit the following report and estimates, with accompanying map, of a survey of Southport Harbor, Connecticut, made by your direction, during the month of September, 1875.

The survey was commenced September 2, 1875, and completed September 8, with but little interruption by bad weather. Tidal observations were made through half a lunation, day tides only being observed. A mean low-water plane was found and bench-marks referring to this plane were established as follows: On the northwest corner of the north beacon, fifth course from the top, elevation, 9.24 feet; and on the northeast corner of Charles Jennings's lower dock, elevation, 9.06 feet. The mean rise and fall of tide is 6.64 feet. The map was made during the winter.

Estimates have been made for a channel 50 feet wide from deep water to the upper docks, as follows:

A channel 5 feet deep at mean low-water will require the removal of about 40,200 cubic yards of sand, to cost about 25 cents per yard	$10,050
Add 10 per cent. for superintendence, &c	1,005
Total	11,055
A channel 4 feet deep at mean low-water will require the removal of about 29,400 cubic yards of sand, to cost about 25 cents per yard	7,350
Add 10 per cent. for superintendence	735
Total	8,085

Rock in place may be met with in the vicinity of White Rock to the amount of from 15 to 20 cubic yards, which it may be necessary to remove in case the harbor is dredged. To do it, would cost from $12 to $15 per yard, say $200 for the whole quantity.

The dike extending north from the shore end of the breakwater and parallel to the channel requires repairing. The walls are in good condition, but the waves have washed out some of the earth filling between them. This should be replaced. It would probably average 2 feet of filling to be placed along the whole length, or about 500 cubic yards of coarse sand and gravel. This, if put in place by scows and barrows, would cost about 30 cents per yard; but if taken from a dredge at work in the channel, the cost of extra handling should not exceed 10 cents per yard. The total cost of repairing the dike should not exceed $150.

Respectfully submitted.

WM. W. STARR, JR.,
Assistant Engineer.

Col. J. W. BARLOW,
Corps of Engineers U. S. A.

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C 7.

NORWALK RIVER, CONNECTICUT.

At the writing of my last annual report work on this river was in progress under a contract with Mr. Emory R. Seward, of Albany, N. Y., dated September 7, 1874, and expiring (by a two months' extension) August 31, 1875. The work was completed August 11, 1875, 36,715 cubic yards having been removed, making a channel 60 feet wide and 6 feet deep at mean low-water, from the railroad-bridge at South Norwalk, to the stone bridge at Norwalk.

The contract price being lower than was estimated, it was found possible, after completing the cut through the Middle Ground, to remove a much larger amount of material from near the railroad-bridge than had been contemplated.

Under an appropriation by act of Congress approved March 3, 1875, after duly receiving proposals, a contract was entered into with Messrs. H. N. and A. J. Beardsley, of Bridgeport, Conn., dated July 21, 1875. The proposed plan of work was to cut a channel 60 feet wide and 6 feet deep, from Gregory's Point, at the mouth of the river, to W. Jennings's wharf, but, as the previous contract had done part of this work during the time of its extension, this appropriation proved sufficient to make the channel from 100 to 120 feet wide below the wagon-bridge and 60 feet wide above this bridge to the lower end of the preceding year's work. The contractors began work September 28, 1875, and finished November 17, 1875, having removed 44,444 cubic yards.

To make the channel 100 feet wide from the railroad-bridge to the Norwalk docks, at the present depth of 6 feet, will cost $30,000. This will give a 100-foot channel all the way up from Long Island Sound, and it is recommended that the project be undertaken. A width of 80 feet will cost about one-half as much, and $15,000 could be advantageously expended for this purpose during the next fiscal year.

Norwalk is in the Fairfield collection-district, and Bridgeport is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $4,302.33.

In a report of survey, dated December 16, 1871, a channel 100 feet wide and 6 feet deep was projected, at a cost of $34,000, the estimates being based on a rate for dredging per cubic yard of 20 cents. On account of unforeseen difficulties, particularly in reference to the dumping, the last contract was the only one that has been let as low as the estimated rates. The amount of material was probably also underestimated, and no allowance was made for the filling, which is an inevitable result where small appropriations make it necessary to continue the work over a number of years. It is believed that the present estimate of $30,000 is sufficiently to fully complete this channel to the originally proposed width.

The following appropriations have been made for the improvement of Norwalk River, and expended in dredging at the rates per yard annexed to each appropriation:

June 10, 1872	$10,000 00	24½ cents.
March 3, 1873	10,000 00	45 cents.
June 23, 1874	10,000 00	23 cents.
March 3, 1875	7,000 00	13½ cents.
Total	37,000 00	

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Money statement.

Amount available July 1, 1875	$12,566 94
Amount expended during fiscal year ending June 30, 1876	12,376 32
Amount available July 1, 1876	190 62
Amount (estimated) required for completion of existing project	30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	15,000 00

C 8.

PORT JEFFERSON HARBOR, LONG ISLAND, NEW YORK.

The appropriation of $15,000 by act approved March 3, 1875, was divided between dredging and stone-work. The latter was for the construction of a jetty on the west side of the harbor entrance and a contract was entered into with Mr. Francis H. Smith, of New York, to deliver stone at the rate of $1.44 per gross ton. Owing to bad weather and several disasters to the vessels employed, Mr. Smith failed to complete his contract by the 30th of June. An extension of ten days was granted, in which time the stipulated amount of stone will be delivered. This will leave the jetty about 475 feet long, of a triangular cross-section, with slopes of 1 on 1, and reaching 4 feet above high-water level. Up to the 30th of June, 3,192 tons of stone had been delivered. The effect of this jetty has been already to collect a very considerable amount of sand and gravel on its western side and to bring the lines of direction of flood and ebb currents nearly parallel. The middle ground opposite the end of the east jetty has been washed down by the concentrated action of the currents, so that now there is 3.5 feet at low water where a year ago it was nearly bare at the same stage of tide. It will be desirable to continue this jetty probably about 600 feet farther, requiring about 7,000 tons of granite, at $1.75 per ton, $12,250.

The contract for dredging was awarded to Mr. Sidney F. Shelbourne, of New London, Conn., at the rate of 27 cents per cubic yard. The contractor displayed a great deal of reluctance in beginning this work. Finally, in October, 1875, he moved a dredge to the locality and worked for a part of two days, removing 165 cubic yards. No further work has been done, and his contract expired by limitation at the close of the fiscal year. I shall, therefore, at an early day, submit a project for doing the work by hiring a dredge for the purpose.

The breakwater on the east side of the harbor entrance is badly in need of repair. There are openings in it so large as to seriously impair its efficiency, allowing sand and gravel to wash freely through. I quote from a report of Mr. G. N. Weaver, inspector of the construction of the jetty:

> Ever since my arrival here I have been greatly impressed with the necessity of having the east breakwater raised and repaired as soon as possible. During every easterly storm this coast is visited by a high sea which entirely covers the work, and, sweeping over the beach, bears a vast amount of material into the channel. There is 200 feet of the shore-end of this work that has become entirely covered with sand and gravel. This portion must have settled very much, for the top of it at present is 3 feet below the surface of the beach.
>
> The whole eastern work is very much in need of repairs. There is but a very small portion that has been raised above high water, and in many places the stones are so large as to leave voids large enough for sand and gravel to pass through freely, forming a shoal just west of the work. The highest part of this shoal is about 25 feet away, and is 3 feet higher than that immediately adjacent to the breakwater.
>
> We cannot expect to realize much improvement at the entrance until this work has been raised; and I would respectfully recommend that this portion of the improvement receive your attention as soon as you find it convenient.

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This breakwater ought also to be extended farther out, in order to prevent sand-washing around the outer end. To carry it to the 9-foot curve would cost, as stated in my last report, about $16,000. Twenty thousand dollars could be expended to advantage during the next fiscal year, to be divided between the old and new works, as may at the time appear most advisable.

Port Jefferson is in the New York collection-district, New York being the nearest port of entry. I have not yet ascertained the amount of revenue collected in New York for the fiscal year ending June 30, 1876.

The first appropriation made for this harbor was in 1871. This and that of the following year were expended in constructing the breakwater on the east side of the entrance. The next appropriation was made in 1875, and has been expended as described in this report. The following is a statement of the respective amounts:

March 3, 1871	$15,000
June 10, 1872	15,000
March 3, 1875	15,000
Total	45,000

Money statement.

Amount available July 1, 1875	$15,988 37
Amount expended during fiscal year ending June 30, 1876	4,982 14
Amount available July 1, 1876, including $2,022.90 due on contracts	11,006 23
Amount appropriated by act approved August 14, 1876	6,000 00
Amount (estimated) required for completion of existing project	22,250 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	20,000 00

C 9.

PECONIC RIVER, LONG ISLAND, NEW YORK.

No work was done on the improvement of this river during the past fiscal year. The channel previously dredged is still in good condition.

There remains a balance of $285.45 of the appropriation made by act of Congress approved March 3, 1873.

C 10.

SURVEY OF THE CHANNEL OF WEST HAVEN HARBOR, NEAR NEW HAVEN, CONN.

ENGINEER OFFICE, UNITED STATES ARMY,
New London, Conn., January 11, 1876.

GENERAL: I have the honor to submit my report, accompanied by that of assistant engineeer, Mr. H. N. Babcock, on the survey of West Haven Harbor, Connecticut.

This survey was authorized by a paragraph of section 2 of an act of Congress making appropriations for certain public works on rivers and harbors, &c., approved March 3, 1875. The survey was made in the latter part of September. Its object was to lay out a plan and make estimates for increasing the available depth of the channel from 2½ to 6 feet at mean low-water.

West Haven is a town of about 3,000 inhabitants, lying just west of the city of New Haven, and separated from it by West River. The

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principal business of the place, which would be favorably affected by the desired improvement, is the traffic in lumber and coal, and ship-building, amounting in the aggregate to about $100,000 per year. The harbor is in an indentation from New Haven Harbor. It is quite completely sheltered, but too far inland to be of any value as a harbor of refuge. The advantages to be derived from the improvement must be considered as only of local importance.

The estimate for dredging the line of the present channel is $11,340. This plan is the only one that, either in feasibility or economy, seems worthy of consideration; it would give a depth at high-water of 12 feet, the rise of tide being practically the same as in New Haven Harbor, 6.06 feet. The length along this channel of water-front which would be available for wharves is about one-half mile.

As far as I have been able to ascertain, there has never been any dredging done in West Haven Harbor, either by the General Government or by private parties.

West Haven is in the New Haven collection-district, and New Haven is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1875, was $345,331.17.

Very respectfully, your obedient servant,

J. W. BARLOW,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. HENRY N. BABCOCK, ASSISTANT ENGINEER.

ENGINEER-OFFICE, UNITED STATES ARMY,
New London, Conn., December 22, 1875.

COLONEL: I have the honor to present the following report, with the map of the survey of West Haven Harbor, Connecticut:

The survey was begun on the 20th of September last, and finished the same month. A base-line 1,575 feet long was chained along the causeway at the upper end of the harbor, and the sounding-stations located by angles from this base. The following points also were carefully located by triangulation, viz:

West gable of Jeremiah Smith's house, Oyster Point.
North gable of north watch-house.
North gable of south watch-house.
Cupola of Harris Eames's house, West Haven.
Spire of Methodist Episcopal church, West Haven.
Iron smoke-stack in Hotchkiss's lumber-yard, West Haven.

The tide-gauge used was placed against the dock of Richards's lumber-yard, and referred to a bench-mark established in 1874 from tidal observations previously made by the United States Coast Survey. Following is a description of its location:

"Spike in top of a fence-post situated on the west side of Howard avenue, Oyster Point, south of Sea street, and at the southeast corner of a yard owned by Mrs. Kelsey, which is south of and adjacent to the school-house grounds. Elevation above mean low-water, 27.464 feet."

The soundings were located by intersecting angles. The specification in the act of Congress under which this survey was made called for a survey of the channel of West Haven Harbor, Connecticut, and it was not deemed advisable to make a topographical survey of the shore. The high-water mark and the corners of the docks were located in connection with the soundings.

The map is drawn to a scale of 200 feet to the inch, and includes all of the harbor available for navigation. Above the causeway is a meadow of considerable area, but not of much effect as a tide-basin, since it is scarcely covered at high-water. The harbor receives also the fresh water from West River, a small stream of about 15 miles in length.

The object with a view to which this survey was asked for was the deepening of the channel from its debouchure into New Haven Harbor to the West Haven docks, so as to gain a depth of 6 feet at low-water; the present available depth is 2.8 feet; the

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length of the channel is 1 mile. To be of use, the dredged channel should be not less than 60 feet wide. This improvement would require the removal of 63,000 cubic yards of mud, at 18 cents per yard, amounting to $11,340. By following more exactly the line of the present channel, a saving of removal of 3,000 cubic yards could be effected at the expense of introducing two additional angles in the channel.

There is in West Haven an opinion in favor of cutting the channel in a southeasterly direction through the flats and "The Beach." This opinion is sustained by the belief that the tide, acting directly through this channel, would keep it open and at the same time would prevent the ebb from depositing material in New Haven Harbor. The expense of this improvement would be about two and a half times as great as the one above considered. I cannot believe, either that a narrow channel through so large a mass of loose sand as "The Beach" would keep open in a southeast storm and flood-tide. The material on "The Beach" and outside is sand and shells, that inside is mud; the depth of the mud in the harbor is very great, some of the wharf-piles being driven down 18 feet before striking solid bottom.

There is no dumping-ground inside the harbor that could be used even at high water without interfering with private oyster-grounds; the distance to the dumping-ground at the mouth of New Haven Harbor is about 5½ miles.

The amount of merchandise received at West Haven by water is about 5,000 tons per annum, valued at over $100,000. At the ship-yard there are built on an average 2 vessels per year, generally three-masted schooners, ranging from 500 to 800 tons burden. The harbor is seldom closed by ice for more than six or eight weeks during the winter. The population of West Haven is about 3,000.

For the above statistics I am indebted to the courtesy of Mr. H. H. Richards.

I was assisted on the survey by Messrs. F. N. Lincoln, N. B. Craig, and W. C. Graham.

Respectfully submitted.

HENRY N. BABCOCK,
Assistant Engineer.

Col. J. W. BARLOW,
Major Corps of Engineers, U. S. A.

APPENDIX D.

ANNUAL REPORT OF LIEUT. COL. JOHN NEWTON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER-OFFICE,
New York, July 14, 1876.

GENERAL: I have the honor to transmit herewith the annual reports upon the works under my charge for the fiscal year ending June 30, 1876.

Very respectfully, your obedient servant,

JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Maj. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

D 1.

IMPROVING HUDSON RIVER, NEW YORK.

Lieut. J. H. Willard, Corps of Engineers, assistant, stationed at Albany, N. Y., has continued to superintend these operations, and from his report I make the following extracts:

No regular and continued surveys were undertaken; but resurveys and examinations were made from time to time, as required. The results have been submitted to

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you as far as they have been completed. They comprise Round and Fish-House Shoals, Cuyler's Bar, the old State dam, Winnie's Bar, Cedar Hill Bar, Coeyman's, and New Baltimore, done last season, and Cuyler's Bar and the Overslaugh, the latter examined twice, and Coeyman's and New Baltimore, done this season. The party is now engaged in resurvey of the upper section from Port Schuyler to Bath.

The levels from Troy to Stuyvesant have been revised and compared with former work. The results from independent lines taken by different parties substantially agree.

Mr. Talcott has proved himself invaluable and untiring; his party is well trained, small in number, but zealous, hard-working men. I have tried the plan of taking young graduates and students from the Rensselaer Polytechnic Institute at Troy, and am well satisfied with the results. These young men are anxious to gain practical knowledge, and are willing to work hard for low pay, and their work is accurate and thorough.

Surveys are required from time to time, not only to discover the action of the works already executed, but also to assist in choosing the location of new dikes. Surveys are likewise necessary whenever it is necessary to construct a new dike or to dredge.

Accurate surveys are not only necessary to carry on a system of river improvement, but they serve actually to promote economy.

The dike at New Baltimore was the only new work put down during the year. It was not begun till late in the season, and though every effort was made to have it finished in time, the sudden cold weather of November 24 overtook the contractor and put an end to any continuous work. The work was accepted and paid for in May, 1876. A cross-dike, to connect the main work with the shore, was let at the same price, after a careful estimate and comparison of cost with other plans. It was finished on November 20, 1875, and was paid for at once, being regarded as outside the contract.

The length of main dike is 2,914 feet, and cost, at $4.84	$14,103 76
The cross-dike is 314 feet, and cost	1,519 76
For the work, 3,228 feet	15,623 52
Inspector's pay, 2 months	166 66
Gross cost	15,790 18

Dredging was done at Cedar Hill, along the middle dike at Coeyman's, and along the new dike at New Baltimore; at Cedar Hill 7,000 cubic yards, at 20 cents, which included lifting a portion of the material over the dike; from Coeyman's bar 12,000 cubic yards were removed, at a cost of 15 cents; at the new dike near New Baltimore 5,000 cubic yards were removed, at a cost of 16 cents.

The amount paid for dredging was $3,919.15; for inspector's pay, $158.67; and for extra labor, $90.00, making, in all, $4,167.82, for about 24,000 cubic yards. This amount was judiciously laid out, as may be seen from the maps made last year and compared with those made this season. It is hoped that the State may relieve us from further work of dredging.

All the dikes suffered to some extent during the winter of 1874–'75, and especially the cheaper ones. I restored those most needing repair, viz: Crib-dike at Hill-House Island, Base Island, Bath, Patroon's, Van Wies, Cow Island, (which I also raised one foot,) Cedar Hill, Castleton, and the dikes at Coeyman's.

Before undertaking the work, I invited proposals for labor and material, and for stone. The labor, iron, and timber were furnished by John B. Marshall, and the stone by A. S. V. Vanderpool, the lowest bidders. The amounts have been given in detail in the vouchers. The amount of stone delivered was 1,962¼ cubic yards. The cost of repair was $1,567.43; of stone, $1,157.87; and the pay of inspector, $54.66; making, in all, $2,779.76. The amount allotted was $4,150.

Last winter was unusually hard on our works. After a careful examination of the damage done by ice, and by currents undermining some of the dikes, I think $5,000 should be reserved for repairs during the summer.

The State appropriated $40,000, to be expended under the direction of the State engineer. The act was approved by the governor in May.

The use of the information compiled in our charts has been offered to the State engineer to serve to locate the lines of dredging, and I am happy to say that under the system now begun of cordial co-operation

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between the State and the United States engineer, excellent results may be confidently expected, both in economy and benefit to navigation.

The dike built during the past fiscal year from Barren Island toward New Baltimore is necessary, in order to re-establish the channel in the old and more natural direction. The preservation of a deep channel along the New Baltimore dike, constructed by the State of New York some years since, has been practically proved to be impossible, without extensive additional works.

The new channel laid out will possess the great advantages of being the track of both flood and ebb tides, whereas the present can only be an ebb-tide channel.

To complete the present improvement, it would first be necessary to dredge at the proposed channel, (to which object the State appropriation will be partially devoted,) and then to cut off the existing channel by a dike extending from the New Baltimore State dike to the middle ground, upon which the light-beacon is situated.

An old cross-dike in the back channel near the head of Bogart's Island, serving only the bad purpose of directing the currents during freshets loaded with sand over the Overslaugh dike into the main channel, and filling up the same with sand, should be removed.

The gap now existing between the Bath and Base Island dikes should be closed, and one of proper length opened in the upper portions of the Base Island dike. It would be well to encourage the growth of brushes and trees upon the dikes, as tending to their consolidation and permanence. With this object, willows have already been planted upon some of the dikes.

Among the dikes of prime importance are the Overslaugh and Shad Island proposed dikes; but, as it appears discouraging to wait longer for appropriations sufficient to construct these in a solid manner, I propose to plant willows along the proposed lines of these structures, adding to these each year, and thus increasing the deposits until they form a bank, which ultimately, and without further assistance, may attain a level a little above low-water. This, being done at small expense, if proved to be practicable, would serve to benefit materially the channels, while the higher level attained as a foundation for future solid dikes would much diminish the cost of such structures.

There are continual applications for grants of land under water from the State. Now, as it is necessary to preserve the back channels in order to maintain a proper tidal flow, and also to lay down a pier-line on the river itself, I would respectfully propose a commission (to include the State engineer) to consider and report upon this subject, with the view of having such report legalized both by Congress and the State legislature. I consider the matter important, and requiring dispatch.

The work is in the fourteenth collection-district. The nearest port of entry is Albany, N. Y. The amount of revenue collected from imports and exports for the fiscal year was $163,701.36; the value of same, $802,639. The amount of commerce and navigation benefited, $500,000,000.

Amount to be appropriated to complete the work	$214,116 47
Amount already appropriated by Congress	770,188 00
	984,304 47
Amount of estimate of 1868	984 304 47

Amount asked to be appropriated for 1877-'78:

Construction of Overslaugh dike	$40,000 00
Removal of Austin's Rock	26,000 00
Total	66,000 00

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Money statement.

Amount available July 1, 1875	$39,770 63
Amount expended during fiscal year ending June 30, 1876	34,255 54
Amount available July 1, 1876	5,515 09
Amount appropriated by act approved August 14, 1876	50,000 00
Amount (estimated) required for completion of existing project	164,116 47
Amount that can be profitably expended in fiscal year ending June 30, 1878	66,000 00

Abstract of bids for constructing dike in the Hudson River between New Baltimore and Barren Island.

Bidders.	First, entirely of stone.	Second, pile-dike.	Third, half dike.
Edgar M. Payne		$7.42 per linear foot	
Stephen Miles	$6.22 per linear foot	5.64 per linear foot	$4.14 per linear foot.
John H. Marshall	6.60 per linear foot	8.84 per linear foot	3.94 per linear foot.
James D. Leary	9.99 per linear foot	7.69 per linear foot	8.99 per linear foot.
P. Sandford & Co	11.50 per linear foot	11.25 per linear foot	9.35 per linear foot.

Abstract of contract for constructing dike in the Hudson River between New Baltimore and Barren Island.

Contractor's name.	Date of contract.	Subject of contract.	Remarks.
John H. Marshall	Oct. 6, 1875	2,900 feet, more or less	To be completed by December 31, 1875.

D 2.

REMOVING OBSTRUCTIONS IN EAST RIVER AND HELL GATE, NEW YORK.

I append herewith extracts from the annual reports to me of Capt. W. H. Heuer, Corps of Engineers, assistant in superintendence of the work of excavating at Hallet's Point and Flood Rock.

HALLET'S POINT.

The end of the last fiscal year found the work of excavation here completed. This year the work has been principally confined to drilling holes in the roof and piers preparatory to the final blast. The drilling was about completed on March 25, and the locating and mapping of the various bore-holes was finished on June 1. The roof of the mine contains 5,375 holes, each 3 inches in diameter and averaging about 9 feet in length. The piers contain 1,385 drill-holes, of which 288 are 2 inches in diameter, the balance being 3-inch holes of about the same length as those in the roof, thus making a total of 6,760 holes, whose aggregate length is 58,874 feet.

In drilling these holes several new rock-drilling machines were experimented with, notably the Rand, Winchester, and Waring drills. The results obtained were satisfactory, and were superior to those obtained by us with the older kinds of machines.

Detailed reports of their performances were furnished you from time to time in my monthly reports of operations.

Many experiments were made here under your direction on the explosive effects of nitro-glycerine confined in rubber and iron tubes varying from 12 to 300 feet in length; also with other explosives, as vulcan-powder, nitro-naphthaline or vigorite, dynamite, and Horsley powder, to test their relative merits (both in their wet and dry states) in breaking up gneiss rock.

A stone wall about 8 feet wide, from 12 to 20 feet high and 150 feet in length, was built nearly parallel to and about 10 feet distant from the inner side of the shaft. It was designed to protect the land back of it from the action of the tidal currents. Several hundred yards of loose rock lying between high and low water marks around the coffer-dam were removed.

The large pumping-engines continue to do fair work. The leakage into the mine has increased to about 700 gallons per minute.

The workmen were discharged as soon as their services could be dispensed with. At present there are only enough men retained to care for the works and attend to the pumps.

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FLOOD ROCK.

When the last annual report was made on this work, operations had just commenced. Since then two shafts, 65 feet apart, have been partially completed. The larger shaft is 10 by 20 feet in plan and is 51 feet deep, its bottom being 41 feet below mean low-water line. The smaller shaft is about 12 feet square in plan and has a depth of 23 feet. The aggregate length of tunnels driven from the two shafts was 229 feet. The rock taken from the tunnels was utilized by throwing it into the river around the shafts and erecting a wall around it so as to obtain a sufficient area, about 4 feet above high-water mark, upon which to place the necessary machinery and workshops to be used in future operations. The foundation so prepared has a length of 183 feet and an average width of 45 feet.

The work is now in such a condition that, were the funds available, we could by using the Hallet's Point machinery keep a dozen rock-drills continually at work. This would enable the machinery to be used to the best advantage and would result in reducing the cost of excavation to a minimum.

Number of feet of holes drilled	13,826
Number of drills sharpened	4,691
Loss of steel by abrasion and dressing	359 pounds.
Cost of drilling per linear foot of holes	42 cents.
Cubic yards of rock removed	1,462
Average drilling required per cubic yard	9 feet.
Average cost of explosives, per cubic yard of rock	93 cents.

It will thus be perceived that all remaining to be done at Hallet's Point is to blow down the rock and to remove all the *débris*, by means of a steam-grapple, which shall be found above the level of 26 feet at mean low-water.

Extensive experiments have been made, under my directions, by Captain Heuer upon various explosives—nitro-glycerine, dynamite, rend-rock, vulcan powder, nitro-naphthaline, (vigorite,) and gun-cotton, (the solid compounds being used both wet and dry)—to test their applicability to the purposes of demolition. At the same time, experiments under my direction have been conducted by Mr. Julius H. Striedinger, assistant engineer, upon wet batteries, wires, and fuzes, with a view to their use in the final blast.

I have in this connection to express my obligations to General H. L. Abbot, U. S. A., in charge of the torpedo-school at Willet's Point, for his revision of the results obtained in my office, with his more extensive and perfect electrical apparatus.

A full description of the method to be adopted will be furnished hereafter; and it is sufficient here to say that we are now ready to contract for the explosives, cartridge-cases, batteries, wires, and fuzes.

The explosion will depend as to time upon the contractors, but it is hoped, if no delay arise from them, that we will be able to explode the mine by the 1st or 15th day of September next.

STEAM-DRILLING SCOW.

The subjoined extracts from the reports to me of Mr. J. H. Striedinger, assistant engineer, in superintendence of the steam-drilling scow, will, it is believed, convey an adequate idea of the work of this machine during the fiscal year ending June 30, 1876:

COENTIES REEF.

GENERAL: I have the honor to report upon operations of the United States steam-drilling scow, resulting in the final removal of Coenties Reef to a depth of 25½ feet at mean low-water, in 99 working days, from May 4, 1875, to August 27, 1875, as follows:

When drilling was recommenced the maximum length of Coenties Reef measured 162 feet, and its maximum width 290 feet within the 25½-foot curve, and the depth available for navigation was 21½ feet at mean low-water.

At the beginning of the season, April 10, 1875, there was introduced into the back

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smoke-box of our boiler, directly above the exit of the tubes and in the throat of the smoke-pipe, a coil heater arranged in the form of a continuous series of small return-pipes, for the purpose of heating the feed-water before its entrance into the boiler.

The dome was also provided with movable iron arms containing 6-inch holes for shifting drill-pipes within the center circle.

These "spectacle frames" are pivoted in the center and are easily swung by the diver to any desired point, and there clamped to the rails on which their outer extremities rest. Two of these radiating tongues are placed in each quadrant of the inner circle, one resting on the top of the dome, the other on the lower inner circle-band, which is a little above the bottom platform.

In addition to the hydrographic survey of Coenties Reef, executed under your direction in 1873, the character of the tidal currents was also investigated, and some soundings were taken off Coenties Reef. The results of these observations were:

The ebb current runs 20 per cent. swifter than the flood current over Coenties Reef.

The velocity of the tidal currents gradually diminishes from the channel end of the reef toward the New York shore. Maximum ebb and flood currents do not set quite in opposite directions, the angle of divergence being 20°.

At mean tides the ebb current assumes, near the center of Coenties Reef, a velocity of nearly 2¾ nautical miles per hour.

For mean spring-tides the above velocities are to be increased 26 per cent., and for mean neap tides to be decreased 21 per cent.

The occurrence of maximum ebb current happens at about twelve hours twelve minutes after moon's transit, that of maximum flood current at six hours nineteen minutes after the moon's southing.

The change of current—slackwater—takes place about one hour and thirty-five minutes after the stands.

Mean rise and fall of tides off Coenties Slip is 4.4 feet.

In spite of the large area of the 25½-foot curve, it was found necessary to change the anchors but twice during the whole time of operations.

A tide-gauge was established at pier 10, East River, in order to secure a constant and reliable reference to mean low-water. When the sight from the scow to this gauge was covered by shipping, another tide-gauge, fastened to the south side of pier 8, was observed by one of the crew, and copies of the tidal records were supplied every fifteen minutes.

The average working-force of the United States steam-drilling scow while engaged on Coenties Reef numbered 43 men, consisting, besides myself, of 1 mechanical draughtsman, 3 divers, 1 chief carpenter, 2 carpenters, 1 engineer, 6 drillers, 1 blaster, 2 blacksmiths and 5 helpers, 17 sailors, 2 firemen, 1 time-keeper on the dredge, and 1 tide-gauger on the scow.

Ledges of rock were disposed of by placing the dome on them and instituting drilling, and small rocky points projecting above the 25½-foot curve by surface-blasting.

No change was made in the general form of the tin shells used to contain the nitro-glycerine charges. The nitro-glycerine was furnished at a temperature of about 65° Fahrenheit by Mr. Warren, and stood well all qualitative tests. It was brought on board the scow nearly two hours before the explosion of the charges, in quantities to cover the blast, and if any nitro-glycerine remained it was taken back to the factory on the Jersey Flats, by Mr. Warren's own men, directly after the blast.

The explosion of the nitro-glycerine charges was chiefly produced by detonating in them low-tension fuses, whose wire bridges were heated by the voltaic current.

The bridges of these exploders were formed of platinum wire of 0.002 inch in diameter, (then the finest platinum wire in the American market,) and had a length of $\frac{3}{16}$ of an inch. Fulminate of mercury was employed as priming, in place of gun-cotton, on account of the great technical difficulties in manufacturing perfect gun-cotton fuses. Those fulminate of mercury fuses can also be exploded by means of the friction battery, but require, in this case, about three times the strength of current as Brown's No. 4 fuses.

The fuses were arranged in divided circuit, each being attached by connecting wires (sample No. 25, size 18 × 9) to the ends of the leading wires, (sample No. 19, size 12 × 5.)

By means of a Morse key, a sounder, and an extremely weak cell, each low-tension fuse was tested with a view of establishing the unbroken condition of its fine-wire bridge.

Each nitro-glycerine cartridge was entered into the drill-hole, after the withdrawal of its plug, by divers, and in order to accomplish the charging of ten holes or more during one slackwater, two divers (Messrs. Conklin and Rogers) attended to this work, each of them following his own plug-lines, and, assisted by his own gang, loaded his part of drill-holes.

Zinc-carbon bichromate batteries were employed for producing the galvanic current necessary for exploding the low-tension fuses.

The condition of each battery previous to the blast was tested by finding the maxi-

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mum length of a platinum wire bridge of 0.004 inch in diameter; it was just able to fuse in short circuit.

When the scow was removed the proper distance from the charged drill-holes, the side chains toward the blast and the two center-chains were well slackened. By doing so the shock imparted to the bottom and the sides of the scow, due to the transmission of explosion by the practically incompressible water, was very much lessened by now acting upon a vessel freely riding at anchor. The careful execution of this rule enabled us to fire large blasts at a comparatively short distance without the slightest inconvenience, save, perhaps, a salt-water shower-bath. For instance, not the least jar was felt on board the scow when 1,003½ pounds of nitro-glycerine, contained in 16 drill-holes, was touched off at a distance of 275 feet.

The blast was touched off by means of a Morse key inserted into the circuit. This arrangement, in place of the touching off with the end of the leading-wire at one pole of the battery, has the advantage of a more convenient closing of the circuit, and does not require the bringing on deck of the batteries. Not one miss-fire happened.

The *débris* were taken up by one large Morris & Cumings dredge, which was anchored alongside the scow, with the bucket toward the less swift flood-current.

Two ebb-anchors and one flood-anchor were run for the dredge; a line made fast to the United States steam-drilling scow substituted the dredge's second flood-anchor chain.

Three stone-scows, each of about 250 tons capacity, were employed. While one was loading, the second one was unloading, and the third one was towing from the dumping-place or waiting to replace the second scow as soon as filled.

The stone-scows were always measured empty and filled, in order to compute, by means of their displacement, their actual stone-load. By careful observations, the average specific gravity of the gneiss forming Coenties Reef was found to be 2.734.

Very heavy stones were, whenever required, broken up by drill-hole or surface-blasts for the dredge. On June 11, 1875, the dredge picked up one blasted stone measuring 6 feet by 6 feet by 5½ feet, and weighing about 15 tons. In the first attempt of raising it one good hoisting-chain of the dredge broke; in the second and successful attempt it took all the steam-power of the dredge to succeed in raising and landing this monster fragment on the stone-scow. Captain Conklin had charge of the dredge. In all, the dome was lowered 40 times for drilling purposes. In addition to the 40 drill-hole blasts, 5 surface-blasts were exploded.

The following exhibits the *résumé* of the drilling and blasting and dredging operations from May 4, 1875, to August 27, 1875:

Total number of holes drilled	271
Total number of feet drilled	2,017.93
Total amount of explosives used were, for 40 drill-hole blasts:	
Pounds of nitro-glycerine	13,402.05
Pounds of dynamite	88
For 5 surface-blasts:	
Pounds of nitro-glycerine	438
Cubic yards of rock removed	1,375
Total time of dredging	41 days, 8 hours, 5 minutes.
Average number of feet of drilled holes to each cubic yard	1.46
Average number of pounds of nitro-glycerine to each cubic yard	10.06
Average number of feet of holes drilled by each machine, per shift of 8 hours	5.49
Average depth of holes, feet	7.36
Average cost of linear foot of hole drilled, including placing of scow, lowering of dome, expenses for drilling, cost of sharpening drills, expenditure of steel, hoisting up dome after drilling operations, and heaving off scow	$3.25
Average cost of sharpening a drill	$1.41
Average number of feet drilled to each sharpening	7.36
Expenditure of steel to each foot of hole drilled	5.6 oz.
Average cost of dredging and dumping one cubic yard of *débris*	$5.34
Cost per cubic yard	$33.89

Considering that the projecting parts of the reef were spread over a very large area, and that it was very difficult to prevent the filling up of the drill-holes on account of the rocky surface having been shattered by futile trials at removal during the last twenty years, the above price per cubic yard of reef removed will appear comparatively very low

No serious accident happened during the whole season.

The results obtained from the introduction of the "coil heater" exceeded even our expectations, inasmuch as by simply utilizing the great amount of heat which was otherwise lost in passing directly from the tubes into the smoke-pipe, there was effected a saving of about 30 per cent. of fuel, besides enabling us to run a larger number of

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drills—9 in place of the previous 7—and giving to the boiler the beneficial effect of the entrance of hot instead of cold water against the heated iron.

I would respectfully state that this improvement is due to Mr. Kelly, and that I have been informed that a gentleman of Brooklyn, Long Island, has, about two months ago, obtained letters-patent for the same invention, while it has been in use on the United States drilling-scow for over one year.

The frames for shifting drill-pipes proved themselves as very practical and time-saving appliances for readily procuring additional drill-holes, in cases where the fixed drill-pipes would not promise the desired number and depth of hole.

Before closing this report, general, I beg leave to acknowledge the able co-operation in the execution of your orders I again enjoyed by Messrs. James R. F. Kelly and Kelles Korrow during the removal of Coenties Reef.

DIAMOND REEF.

The operations of the United States steam-drilling scow engaged on Diamond Reef, New York Harbor, from October 8, 1875, to November 24, 1875, inclusive, resulted in the removal of a part of the reef to a depth of 26 feet at mean low-water. Work on the remaining portion had to be suspended in consequence of an exhaustion of the funds allotted for this reef.

When drilling was commenced the maximum length of Diamond Reef measured 490 feet, and its maximum width 256 feet within the 26-foot curve; also the draught of water was 19 feet at mean low-water over its shallowest point.

This obstacle to navigation consists of gneiss, vertically stratified, overlaid in many places with bowlders, sand, and clay.

Diamond Reef being but 600 yards to the southwest of Coenties Reef, what was stated in reference to tides and tidal currents there holds nearly equally good here, the only difference being in the force of the tidal currents, which run over Diamond Reef at a relatively diminished rate, the velocity of the maximum ebb current being 2 nautical miles, and of the maximum flood current 1.35 nautical miles per hour at mean tides.

The greatest number of holes simultaneously fired on this reef was twenty-one, with a total charge of 1,146 pounds of nitro-glycerine, this being the largest nitro-glycerine blast on our record.

There has not been a single miss-fire to note.

The dome was lowered 19 times altogether for drilling purposes. In addition to the 19 drill-hole blasts, 4 surface-blasts were exploded.

Two collisions happened while anchored over Diamond Reef, but both of them without serious consequences to the colliding vessels

The following is a *résumé* of the drilling, blasting, and dredging operations:

Total number of holes drilled	131
Total number of feet drilled	1,318.5
Total amount of explosive used:	
For 19 drill-hole blasts, pounds nitro-glycerine	8,307
For 4 surface-blasts, pounds nitro-glycerine	274
Cubic yards rock removed	971.7
Total time of dredging	23 days, 8 hours, 15 minutes.
Average number of feet of drilled holes to each cubic yard	1.35
Average number of pounds of nitro-glycerine to each cubic yard	8.83
Average number of feet of holes drilled by each machine per shift of 8 hours.	11.79
Average depth of holes, feet	10.03
Average cost of linear foot of hole drilled, including placing of scow, lowering dome, expenses of drilling, cost of sharpening drills, expenditure of steel, hoisting up dome after drilling operations, and heaving off scow	$2.05
Average cost of sharpening a drill	$1.41
Average number of feet drilled to each sharpening	10.03
Expenditure of steel to each foot of hole drilled, ounces	4.28
Average cost of dredging and dumping one cubic yard of *débris*	$4.64
Cost per cubic yard	$24.53

DETAILS OF DREDGING OPERATIONS ON THIS REEF FOR THE MONTHS OF JUNE AND JULY, 1875, CARRIED ON WITH A VIEW OF EXPOSING THE COVERED-UP ROCK.

Cubic yards of mud, sand, clay, and bowlders removed	1,481
Total time of dredging	28 days, 8 hours, 22 minutes.
Average cost of dredging and dumping one cubic yard of said materials	$3.39

In order to give to navigation the maximum benefit to be derived from the use of the small appropriation received for the removal of Diamond Reef, the most projecting

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points, particularly those near the channel edge of the reef, were drilled and blasted first. Since this *modus operandi*, as may be expected, seldom enjoys the advantages of "face-blasting," the effect of the explosives was comparatively smaller; again, the work of the dredge being chiefly confined to narrow, deep, and isolated craters, was also less efficacious. Hence, it can be easily accounted for that, notwithstanding the operations of the scow on Diamond Reef having been pursued with the usual energy, and guided by additional experience, yet the cost per cubic yard removed was higher than on Way's Reef, and on the reef off East One hundred and twenty-fifth street, Harlem River. Still, it is believed that with a liberal amount of funds at hand, Diamond Reef could be removed relatively quicker and cheaper than the above-named obstructions.

In consequence of lack of resources, no submarine drilling and blasting work was undertaken by the United States steam-drilling scow this spring, which is much to be regretted, because these interruptions deprive us of the means of keeping a well-organized crew together, chiefly consisting of sailors, who, besides being first-class seamen, have learned to become clever drillers, good diver-tenders, and careful handlers of explosives while engaged on the scow.

Amount asked to be appropriated for the fiscal year ending June 30, 1878:

Work of steam-drilling scow on Diamond Reef, Frying Pan, and Shell-drake	$150,000 00
Excavations at Flood Rock, (Middle Reef)	450,000 00
	600,000 00

ORIGINAL ESTIMATE.

Reefs at Hell Gate and Diamond and Coenties Reefs		5,139,120 00
Amount appropriated		1,690,000 00
Deduct amount reverted to United States Treasury	$3,158 55	
Deduct amount allotted for Harlem River	11,000 00	
		14,158 55
		1,675,841 45
Amount expended		1,621,399 99

Amount expended during year ending June 30, 1876:

Excavations at Hallet's Point	88,530 52
Excavations at Flood Rock	22,393 19
Steam-drilling scow	74,527 00
Allotment for Harlem River	7,673 26
Contingencies, engineering, &c.	5,453 03
	198,577 00

Money statement.

Amount available July 1, 1875	$252,718 46
Amount expended during fiscal year ending June 30, 1876	198,577 00
Amount available July 1, 1876	54,141 46
Amount appropriated by act approved August 14, 1876	250,000 00
Amount (estimated) required for completion of existing project	3,213,278 55
Amount that can be profitably expended in fiscal year ending June 30, 1878	600,000 00

D 3.

DREDGING MUD-BARS IN HUDSON RIVER, OPPOSITE JERSEY CITY.

Under contract with Messrs. Curtis, Fobes & Co., dated August 18, 1875, 105,924 cubic yards of soft material was dredged from that portion of the river in front of Jersey City, extending from a short distance above the Jersey City ferry to a short distance south of the Cunard docks. The contract expiring by limitation on December 1, 1875, authority was granted to continue the work at the contract-price by hired labor, and under this arrangement 57,715 cubic yards were removed, making a total of 163,639 cubic yards of material removed.

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ORIGINAL ESTIMATE.

Dredging 221,300 cubic yards, at 40 cents	$88,528 00
Contingencies and engineering	13,279 20
	101,807 20

Money statement.

Amount available July 1, 1875	$23,756 63
Amount expended during fiscal year ending June 30, 1876	23,655 58
Amount available July 1, 1876, including $93 due on contracts	101 05
Amount (estimated) required for completion of existing project	76,807 20

Abstract of bids for dredging mud-bars in Hudson River, New York.

Bidders.	Price per cubic yard.
James D. Leary	14 cents, measured in scow.
Atlantic Dredging Company	17½ cents, measured in scow.
Curtis, Forbes & Co	12½ cents, measured in scow.

Abstract of contract for dredging mud-bars in Hudson River, New York.

Contractor's name and address.	Date of contract.	Subject of contract.	Remarks.
Curtis, Fobes & Co., Portland, Me.	Aug. 18, 1875	50,000 cubic yards, more or less.	To be completed by December 1, 1875.

D 4.

IMPROVING HARLEM RIVER, NEW YORK.

The subjoined extracts from the report to me of Mr. J. H. Striedinger, assistant engineer, in superintendence of the steam-drilling scow, will, it is believed, convey an adequate idea of the work done during the fiscal year ending June 30, 1876:

Operations were conducted with the United States steam-drilling scow, and resulted in the removal of the reef off East One hundred and twenty-fifth street, in the Harlem River, New York Harbor, from a depth of 9 feet to that of 14½ feet at mean low-water, and in widening the channel 120 feet, in 36 working days from August 27, 1875, to October 7, 1875, inclusive.

The main channel is on the New York side of the river; the river to the eastward of the reef is only safe to navigate near high-water. The river-bottom is muddy opposite One hundred and twenty-eighth street, and stony near One hundred and twenty-third street.

The water is pretty clear, particularly during the first quarter of the ebb, thus enabling the diver to distinguish objects in depths of 21 feet.

There are at present plying between Harlem and the lower part of New York City two lines of steamboats, of which the Harlem and New York Navigation Company runs 4 steamers, making on an average 23 round trips, or 46 passages, per day.

The Morrisania Steamboat Company, being the other steamboat line, runs 2 steamers, averaging daily 10 round trips, or 20 passages. Besides the large and swift side-wheel steamers belonging to these lines, there are tows of a freight-line which connect with the Port Chester Railroad, and numerous craft of other kind frequenting the Harlem River.

When drilling was commenced, the maximum width of the 12-foot low-water channel of the Harlem River between the reef to be removed and the New York shore was but 108 feet, and the shallowest point of the rocky obstruction laid 9 feet below mean low-water level.

The reef runs in a northeasterly direction, and consists of gneiss, having a dip of about 75°. The positions of the drill-holes were plotted by myself from my instrumental observations taken on Randall's Island during the time the drilling-engines were at work.

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Owing to the existence of considerable drifts of fine sand over the reef, nearly every hole, after the withdrawal of the drill, required the insertion of an empty cartridge projecting some 15 inches above the river-bottom.

The charges consisted of nitro-glycerine in tin cartridge-cases.

The average working force of the scow while engaged on the One hundred and twenty-fifth street reef numbered 48 men.

On account of the close proximity of the obstruction to the land, comparatively small blasts were fired in the beginning, but having gradually increased the number of drill-holes and the amount of explosive, until we reached as high as 16 of the former with a total charge of 710½ pounds of nitro-glycerine, we found that even this quantity could be exceeded with safety, because the stratification of the reef running nearly parallel to the shore, the effect of an explosion was felt more in a northeasterly and southwesterly direction than along the shore just opposite to the reef.

Not one misfire happened.

The blasted rock was partly taken up by Messrs. Morris & Cumings's dredge, which was set to work whenever the greater part of the reef was covered with the *débris* of the blasts.

A considerable portion of the dredging had to be left undone, owing to the exhaustion of the funds allotted for the removal of this reef.

In all, the dome was lowered 13 times for drilling purposes. In addition to the 13 drill-hole blasts, 2 surface blasts were exploded.

The following exhibits the *résumé* of the drilling, blasting, and dredging operations:

Total number of holes drilled	102
Total number of feet drilled	931.16
Total amount of explosives used:	
For 13 drill-hole blasts, pounds nitro-glycerine	5,640.5
For 2 surface blasts, pounds nitro-glycerine	133.5
Cubic yards rock removed	1,003
Total time of dredging, 12 days, 1 hour, 5 minutes.	
Average number of feet of drilled holes to each cubic yard	0.93
Average number of pounds of nitro-glycerine to each cubic yard	5.75
Average number of feet of holes drilled by each machine per shift of 8 hours	4.89
Average depth of holes, feet	9.02
Average cost of linear foot of hole drilled, including placing of scow, lowering of dome, expenses for drilling, cost of sharpening drills, expenditure of steel, hoisting dome after drilling operations, and heaving off scow	$3 24
Average cost of sharpening a drill	$1 12
Average number of feet drilled to each sharpening	6.01
Expenditure of steel to each foot of hole drilled, ounces	4.6
Average cost of dredging and dumping one cubic yard of *débris*	$2 32
Cost per cubic yard	$16 53

ORIGINAL ESTIMATE.

I.	Piers Nos. 1, 3, and 4, of old bridge off foot of East One hundred and fourteenth street, Harlem, 674.2 cubic yards, at $6 per cubic yard	$4,045 20
II.	Candle-Factory Reef, foot of East One hundred and twenty-second street, Harlem, 1,149.46 cubic yards, spread over an area of 2,529 square yards, at $72.81 per cubic yard	83,703 00
III.	Flat rock off foot of East One hundred and twenty-fifth street, Harlem, 304 feet from Harlem shore, 333.6 cubic yards, spread over an area of 508 square yards, at $97.13 per cubic yard	32,404 00
IV.	Small rock in midchannel off East One hundred and twenty-fifth street, Harlem, 470 feet from Harlem shore, 23.9 cubic yards, spread over an area of 122 square yards, at $194.56 per cubic yard	4,650 00
V.	Small rock at the mouth of Mott Haven Canal, 470.59 cubic yards, spread over an area of 261.2 square yards, at $45 per cubic yard	21,176 55
	Contingencies, 15 per cent. of the above	21,896 82
	Total	167,875 56

Amount appropriated	$10,000 00	
Amount allotted from East River and Hell Gate	11,000 00	
		$21,000 00
Amount expended		21,000 00

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Money statement.

Amount available July 1, 1875	$17,673 26
Amount expended during fiscal year ending June 30, 1876	17,673 26
Amount (estimated) required for completion of existing project	146,875 56
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

SURVEY OF HARLEM RIVER FROM WARD'S ISLAND TO THE MOUTH OF SPUYTEN DUYVIL CREEK, NEW YORK.

Supplementary report.

UNITED STATES ENGINEER OFFICE,
New York, February 10, 1876.

GENERAL: In the report made February 18, 1875, upon the examination and survey of the Harlem River from Ward's Island to the mouth of Spuyten Duyvil Creek, the features of these streams in their present condition, and the changes which would be experienced after the proposed plans were executed, were both described in as much detail as was necessary for the comprehension of the subject. In that report the computation of the velocities of the improved river was based upon the slopes actually observed during spring tides; these have since been reduced to mean tides and the maximum mean velocities calculated.

It would be better for the flow of water if artificial banks, parallel with each other, could be raised throughout the whole course of the river, but as the convenience of commerce demands slips, basins, and piers, these, although at some detriment to the useful effect of the improvement, must be provided.

The outer pier-lines on either bank should be parallel throughout, and at the same distance apart, in order to secure as uniform a water-way as possible, for the reason that the velocities in both directions will depend upon the cross-sections, and a decided difference in these must lead to the formation of shoals or cause very unequal depths.

There are 4 lines exhibited on the general map along which the connection between the Harlem and Hudson Rivers might be made.

1. Sherman's Creek, Inwood (or Tubby Hook.)
2. Sherman's Creek, bend of Spuyten Duyvil Creek near Johnson's Foundery.
3. Cut through Dykeman's Meadows.
4. Spuyten Duyvil, at King's Bridge.

The first two lines involve large excavations, and probably heavy land damages, and would lead to such division of the northern part of New York Island as might prove objectionable to the public. My report of February 18, 1875, discussed the cut through Dykeman's Meadows, but the line by way of King's Bridge being preferred, it was found, by many influential citizens, supplies the reason why comparative projects and estimates for the two locations are herewith presented.

This comparative estimate includes those parts only of the two schemes where the locations are different; that is, from a point 1,200 feet below Fordham Bridge to the east side of Johnson's Foundery.

The excavation of the rock is estimated in both cases to a depth of 18 feet below mean low-water, and of the earth to a depth of 15 feet below the same datum.

ESTIMATE.

1. The cut thus defined through Dykeman's Meadows	$1,963,000
2. The same through Spuyten Duyvil, by way of King's Bridge	3,321,000
Difference of estimate in favor of the first	1,358,000

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These estimates do not include land and property damages. The cut through Dykeman's Meadows would pass through 19.51 acres of land, mostly unimproved, and of salt meadow, and necessitate the removal of six buildings.

The cut via King's Bridge, through 3.96 acres of property, mostly improved, 16.7 acres of salt meadow, and would require the removal of 360 feet of substantial bulk-head and of eleven buildings.

The next question is, whether the bend by way of King's Bridge, largely in excess of that through Dykeman's Meadows, would influence too unfavorably the tidal exchange.

The maximum mean velocities, (corresponding to the maximum slopes obtained from the mean tidal curves,) corrected for bends, were found to be—

	Cut via King's Bridge.	Cut via Dykeman's Meadows.
	Feet.	*Feet.*
From Harlem to Hudson	3.599	3.713
From Hudson to Harlem	3.536	3.639

The difference between the two sets of velocities is not great, and hence it might be inferred that, so far as the tidal exchange is in question, the cut by way of King's Bridge would meet the requirements. The mean velocities thus obtained correspond to the mean wetted perimeters of the particular slopes, and although not isochronal with the actual period of these slopes, must be calculated from them as effects from causes.

By the same process the mean velocities from each particular slope, or from as many as might be necessary to construct a curve of velocities, might be separately calculated for the two tides, and results interesting to the future regimen of the river would probably be the fruit of such labor. It was not necessary, however, at this time to enter into lengthened calculations which would not change the conclusions already arrived at in regard to this river.

The cut via King's Bridge is preferred by some because of the idea that the other, through Dykeman's Meadows, by taking off the body of the water, would influence injuriously the present King's Bridge channel, causing it to silt up, and thus destroy the drainage of a section of country of which this channel is now the outlet. But this supposition is wide of the truth, for in fact it would be a judicious recommendation to increase somewhat the cross-section of the King's Bridge channel, (after making the cut at Dykeman's,) in order to afford a freer flow of tides, which would be somewhat obstructed by the bend of the Dykeman's channel.

Again, it is said that if the Dykeman's cut be made, two dredges instead of one would be required for the King's Bridge road. This is true; but, on the other hand, if the King's Bridge channel be chosen as the line of improvement, the low bridge now existing, which has no draw, must be replaced by a high bridge or tunnel, and the present Fordham bridge, which is of the same character, must also be replaced after a similar fashion.

This is all that needs to be said by way of comparison of the two lines.

Whatever line of improvement be adopted by the Government, I beg leave to reiterate the substance of what was said in the previous report, of the necessity, before work is actually begun, of a clear understanding and definite agreement concerning the character of future bridges and of the modification of existing ones; the depth at which all tunnels should be driven, and the settlement of land-damages. The contour

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lines of the topography have been copied from maps of the department of parks.

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. Engineers, Bvt. Maj. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

D 5.

IMPROVING PASSAIC RIVER, NEW JERSEY.

BELLEVILLE BAR.

The removal of the shoal at the upper end of the dike, of which mention was made in my last annual report, was completed in the month of July, 1875.

In the month of September the cut through this bar was swept over, and some loose stones were found in the channel and removed; also a projection of solid stone, on which it was necessary to make a surface-blast, using 36 pounds of Vulcan powder, which broke it up, and the pieces were removed.

In sweeping this channel there was found a collection of sand which shoaled the channel some $\frac{8}{10}$ of a foot, which was probably due to the obstructing of the east draw of the bridge by the *débris* of the bridge, which took fire August 21, 1875, and fell into the draw. This, when the bridge was rebuilt, was removed; but a quantity of stone, which either fell or was thrown into the draw, still remains and renders it unavailable for navigation. The bridge is used by the Midland Railroad Company, who should be held responsible for this state of things.

RUTHERFORD PARK BAR.

The small drilling-scow was engaged in straightening the cut through this bar by removing projecting masses of bed-rock, the stone in many cases requiring to be drilled and blasted, when it was taken up by means of a small grapple rigged on the drilling-scow. Thirty-seven surface-blasts were made and fifteen holes drilled to an average depth of 5 feet each.

HOLSMAN'S BAR.

Work on this bar was commenced by the small drilling-scow, followed by a dredging-machine hired by the day.

The small drilling-scow was engaged in removing stone from the reef, so that the dredging-machine could commence operations. With the dredging-machine two cuts were made through the bar, giving a width of 50 feet at the top and 40 feet at the bottom, and 1,300 feet long, with a depth of 6 feet at low-water.

A small bar above Holsman's was also removed by the dredging-machine, making a cut about 300 feet in length.

Original estimate	$123,926 00
Amount appropriated	90,000 00
Amount expended	89,563 53

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Money statement.

Amount available July 1, 1875	$17,234 10
Amount expended during fiscal year ending June 30, 1876	16,770 63
Amount available July 1, 1876	463 47
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	24,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	24,000 00

D 6.

IMPROVING EAST CHESTER CREEK, NEW YORK.

This work is still awaiting the result of the efforts of the State commissioners appointed to purchase and condemn certain marsh-lands in the vicinity of Lockwoods, through which the proposed channel will be cut. There has been considerable delay experienced by the commissioners in obtaining a title to all the several parcels of land required, and until the whole matter was satisfactorily adjusted, I would not agree to begin the construction of the project for the improvement.

I have been informed within a few days that the arrangements of the commissioners have been perfected with regard to all the parcels of land save one, and that at an early date I may expect to be officially informed that the legal impediments to a recommencement of operations will have been removed.

Some further surveys have been made, in order to determine the best line for the cut through the land near Lockwoods, and which the commissioners are endeavoring to secure.

ORIGINAL ESTIMATE.

Basin, purchase of site, 18 acres, at $150	$2,700 00
Excavation to level of mean low-water, 200,000 cubic yards, at 40 cents	80,000 00
Excavation of cut, 60,000 cubic yards, at 40 cents	24,000 00
Diking and revetting banks of cut	12,000 00
Engineering and contingencies	17,800 00
Total	136,500 00
Amount appropriated	$37,000 00
Amount expended	6,179 18

East Chester Creek is in collection-district No. 10.

Money statement.

Amount available July 1, 1875	$32,519 79
Amount expended during fiscal year ending June 30, 1876	1,698 97
Amount available July 1, 1876	30,820 82
Amount (estimated) required for completion of existing project	136,500 00

D 7.

HARBOR AT PORT CHESTER, NEW YORK.

There being no appropriation for this work, no operations were conducted during the year.

Amount necessary to complete the original project, $84,632.

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ORIGINAL ESTIMATE.

Removing rocks and building breakwater	$96,632 00
Amount appropriated	12,000 00
Amount expended	9,763 30

Money statement.

Amount available July 1, 1875	$2,236 70
Amount available July 1, 1876	2,236 70
Amount (estimated) required for completion of existing project	84,632 00
Amount that can be profitably expended in fiscal year ending June 30, 1878, to complete the removal of sunken rocks	60,000 00

D 8.

IMPROVING HARBOR AT RONDOUT, N. Y.

No appropriation was made for this work for this year.

During the winter of 1874–'75, the ice caused considerable damage to the north dike, and the following allotments were made for repairs to the pile-dike and to the crib sunk at the end of the dike:

Repairs of harbors on the Atlantic coast	$762 18
Contingencies of rivers and harbors, &c.	237 82
	1,000 00

ORIGINAL ESTIMATE.

North dike	$41,600 00
Branch dike	34,400 00
South dike	59,600 00
Dredging channel	14,400 00
Contingencies and engineering	22,500 00
Total	172,500 00
Amount appropriated	$30,000 00
Amount expended	29,990 69

Money statement.

Amount available July 1, 1875	$9 31
Amount available July 1, 1876	9 31
Amount appropriated by act approved August 14, 1876	30,000 00
Amount (estimated) required for completion of existing project	112,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	74,000 00

D 9.

IMPROVING CHANNEL BETWEEN STATEN ISLAND AND NEW JERSEY.

No work has been done during the year, as no appropriation was made.

The Board of Engineers appointed to examine and report a plan for the further improvement of this channel made their report December 15, 1875.

ESTIMATE OF BOARD OF ENGINEERS.

Dredging 230,000 cubic yards, at 16 cents	$36,800 00
Contingencies, 10 per cent	3,680 00
	40,480 00

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Money statement.

Amount available July 1, 1875	$254 24
Amount expended during fiscal year ending June 30, 1876	24 50
Amount available July 1, 1876	229 74
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	30,480 00

BOARD OF ENGINEERS.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., December 18, 1875.

SIR: I have the honor to submit the report of the Board of Engineer Officers convened by Special Orders No. 74, Adjutant-General's Office, April 26, 1875, to comply with section 3 of the river and harbor act of March 3, 1875, which provides "that the Secretary of War shall convene a Board of Engineers to examine and report at the next session of Congress a plan for the improvement of the channel between Staten Island and New Jersey."

An examination and survey of this channel, with the view to its improvement, was provided for in the act of June 10, 1872. This duty was assigned to Lieut. Col. John Newton, Corps of Engineers, who submitted a report thereon, suggesting two modes of improvement, the one permanent by means of dikes and dredging; the other by dredging alone, but requiring continued repetition of the same process. The former was adopted, and the appropriation of June 23, 1874, was applied to the building of about 2,240 feet of dike, as a commencement of the permanent plan.

The Board believe in the efficacy of this dike system of improvement, as projected by Lieutenant-Colonel Newton, to produce and maintain a deep-water channel, and that it will secure a channel of sufficient depth to meet the present and prospective wants of commerce; but they do not recommend the continuance of the work, on the ground that, whatever may have been the prospective requirements of commerce on this route three years ago, its present needs (owing to a change in the location of the principal shipping port for coal in vessels of large draught) do not call for a 14-foot channel to be attained by the construction of dikes at large cost, but that the existing channel can be sufficiently improved by dredging to a depth of from 10 to 11 feet at mean low-water to accommodate the present commercial interests; and they submit a plan in accordance with which they recommend that this deepening and widening should be effected, with an estimate of cost thereof, for a depth of 11 feet and width of 500 feet, of $40,480.

This improvement will, however, require small expenditures, from time to time, for its maintenance.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

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REPORT OF THE BOARD OF ENGINEERS.

ARMY BUILDING,
New York, November 30, 1875.

GENERAL: The Board of Engineers constituted by the following order:

[Special Orders No. 74.]

WAR DEPARTMENT, ADJUTANT-GENERAL'S OFFICE,
Washington, April 26, 1875.

[Extract.]

* * * * * * *

4. In accordance with section 3 of the act of Congress approved March 3, 1875, published in General Orders No. 34, March 23, 1875, from this office, a Board of Engineers, to consist of Col. Z. B. Tower, Lieut. Col. H. G. Wright, Lieut. Col. John Newton, Lieut. Col. J. D. Kurtz, will convene in the city of New York on the 12th day of May, 1875, or as soon thereafter as practicable, to examine and report a plan for the improvement of the channel between Staten Island and New Jersey.

Capt. William H. Heuer, Corps of Engineers, will report to the Board for duty as recorder.

* * * * * * *

By order of the Secretary of War.

E. D. TOWNSEND,
Adjutant-General.

met at the Army building, New York, May 12, 1875, all the members and the recorder present.

From General Newton, verbally, and from his general and special reports, and plans presented in illustration thereof, aided by Coast-Survey charts and by a visit to, and personal examination of, the line of channel-improvement proposed, the Board were enabled to inform themselves as to the nature of the problem submitted for their consideration and report.

Other questions growing out of this contemplated improve ment, involving riparian rights, local privileges and usages, and the wishes and interests of the Delaware and Raritan Canal Company, were fully set forth by General Newton. The parties whose interests were thus involved expressed a desire to present their views relative to the channel-improvement under consideration.

Their request was willingly and promptly acceded to; maps of the locality were offered them, and they were asked to present their views to the Board in writing. A reply was received from Mr. J. W. Mersereau only.

Having investigated the main subject at issue, and the various questions connected therewith, we now submit the following report thereon, with a method of channel-improvement which, in our opinion, will meet the present needs of commerce, though it will not be of a permanent character, but will rather lead to small expenditures from time to time for its maintenance.

REPORT.

A description of the channel under examination, with a brief notice of the plan proposed for its improvement by General Newton, and of the opposition raised thereto, seems necessary for a ready comprehension of the whole subject involved in this report.

The channel between Staten Island and New Jersey consists of Kill von Kull, separating the north part of said island from Bergen Point; of the southern waters of Newark Bay, *i. e.*, the present narrow passageway for vessels passing between Shooter's Island and the New York shore, and thence by a curved line around the corner stake-light to Elizabethport; and of Arthur Kill, extending from Newark Bay to Perth Amboy, where its waters open into Raritan Bay.

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The waters of Kill von Kull are deep and wide, and present no obstructions to navigation other than those due to the tidal currents which flow contrariwise to those of New York Bay between the city of New York and Staten Island, and hence, in their passage to the city, vessels must meet head-currents in one or the other portion of the route.

The channel of Arthur Kill, in portions, is narrow and winding, its soundings showing a minimum depth, at a few points only, of from 13 to 14 feet at mean low-water. These depths could be increased without involving large expenditures; but as at high-water a draught of about 17 feet can pass these shoalest places, the present commerce of this kill would not, in our opinion, justify expenditures to give its channel a greater depth. The passage-way for vessels crossing the southern waters of Newark Bay, from Elizabethport to Kill von Kull, has a minimum depth at mean low-water of about 9½ feet. The western portion of this channel, where shoal, is narrow and curved, and does not retain even this depth of 9½ feet throughout its width. Though with favorable tides, and currents, and winds sailing-vessels of 13 feet draught may safely pass through this channel, the general commerce of these waters must be confined to shipping of less draught. The Coast Survey chart, prepared more than thirty years ago, shows a minimum depth in Arthur Kill channel of 10 feet at one point, and of 11 and 12 at others. The increased use of this channel since that date seems to have improved it, and there is no reason for apprehending any unfavorable change to its regimen if left undisturbed.

Its influx and reflux tidal waters, aided by the stirring-up effects of passing steamers and other vessels, seem to have removed silt deposited on these shoal places of the channel. This same chart shows by the bottom-curves that the flood-tide, by virtue of its onward moving or living force, extends its erosive effect for a distance of about 1,200 yards into Newark Bay before losing that concentrated force by dispersion.

As the outflowing waters of the reflux tide are not concentrated until they enter Arthur Kill, their erosive effect in Newark Bay is of little or no effect upon this bay channel. The influx waters of Kill von Kull, with a cross-section many times larger than those of Arthur Kill, and a more rapid flow, mainly pass around Bergen Point and go northward. A portion, however, by virtue of its onward force, and by reason of the widening of the water-way, drives forward between Staten and Shooter's Islands, eroding there a deep channel, and thence passes with a curve to be lost in the bay-expanse northward. The bottom-curves on the chart show that the erosive effect of this influx reaches toward that of Arthur Kill, but that the velocity of both currents is so far diminished by dispersion as to leave between the 10-foot curves of the two channels a wide bar, shoaling up in former times to a depth of 5 feet at mean low-water.

The reflux tide by the way of Kill von Kull is, in the main, the reverse of the inflowing, and its erosive effects are favorable to the maintenance of the existing channels. The principal channel of Newark Bay approaches the eastern shore in its southern portion, and in its upper meets the united waters of the Passaic and Hackensack Rivers, and connects them with Kill von Kull, through which they mainly flow into New York Bay.

From this review it will be seen that there was formerly no continuous channel across the south waters of Newark Bay to Kill von Kull, but that a shoal of from 5 to 6 feet of water thereon at low-tide, of many yards in extent from east to west, lay across the passage-way from Elizabethport channel to that of Shooter's Island. The development of commerce on these waters by the construction of the Delaware and Raritan

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Canal, in connection with the rapid growth of our country in the last thirty or forty years, and with the advance of Elizabethport as a shipping terminus of the Central New Jersey Railroad, has called into use large transport-fleets of sailing-vessels, tow-barges, propellers, and other steamers, on this passage-way between Staten Island and New Jersey, which, by frequent and almost continuous transit to and fro, have stirred the soft, muddy bottom of the shoal in question, and removed the floating silt so as to increase the depth thereon almost 4 feet—in fact, have created a useful channel, navigable at all stages of the tide by small sailing-vessels and propellers, and by canal-barges towed by steamers, which formerly could pass over this route only toward the period of high-water. It is stated by Mr. John Bonnell, harbor-master of Elizabethport, that about 5,000,000 tons of freight pass through the Delaware and Raritan Canal yearly, and that other ports in New Jersey have a commerce of about 3,000,000 tons. While almost all of the first amount passes through the channel between Staten Island and New Jersey in vessels and barges, it is presumed that the greater part of the 3,000,000 tons also takes the same route, as Elizabethport still continues to be, to a large extent, the coal-shipping port for the Central Railroad of New Jersey. It is readily seen that barges under tow and small vessels that can pass the Raritan Canal will find no serious difficulty from the shoalness of the water in the channel across Newark Bay, the minimum depth of which is about 9½ feet. Nevertheless, the narrowness of the channel maintaining that depth at low-water will inconvenience them somewhat, as well as sailing-vessels, when the currents and winds are unfavorable, and especially when meeting large tows, and when transports are numerous in the curved and narrow portions of the channel near the corner stake-light.

It was probably the presentation of these inconveniences and impediments to navigation in the channel across Newark Bay that induced the Congress of the United States, by act approved June 23, 1874, to appropriate $50,000 for "improving the channel between Staten Island and New Jersey." To General Newton, lieutenant-colonel of engineers, was assigned the duty of presenting a project for this expenditure.

This project, in accordance with his plan of improvement submitted in 1873, was approved by the Chief of Engineers July 13, 1874. This plan, as well as the general reasons in support thereof, is set forth in his report of February 21, 1873, and in his communication of May 12, 1875.

This Board concur with General Newton as to the efficacy of his plan to produce and maintain a deep-water channel, believing that his reasoning thereupon, while correct in principle, would be found sound if practically tested. This plan consists simply in continuing Arthur Kill between two dikes to the deep channel on the east shore of Newark Bay. These dikes will not follow the present crooked channel, but will pass to the north of Shooter's Island, the south dike probably turning up the bay toward the main channel, its direction and length, however, being determined in the progress of construction. It is apparent that, to leave a suitable opening for intercepting a sufficient portion of the outflowing waters from the bay above that they may be turned seaward through Arthur Kill, the north dike should not be prolonged as far east as the south. To illustrate this plan more fully, let us suppose that the flats of Newark Bay above the proposed north dike were land, and that Staten Island extended to the proposed south dike, leaving the main channel of the united rivers in their course to Kill von Kull undisturbed. The form would be that of a delta, dividing the united river-waters, so that in reflux and influx about the same relative portions would flow

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through the two kills as at present. It seems impossible to escape the conclusion that, under such conditions, the regimen of the two branches would not be changed, or that it would not vary essentially from the result to be obtained by General Newton's project further than this, that, while Newark Bay exists, a larger body of water with the rising tide flows in by the two kills to fill it, and thence outward to empty it; thus giving rise in both kills to greater rapidity of current and erosive effects, a circumstance favorable to the maintenance of the present depth of these kills.

The southern dike was commenced at its western end November 4, 1874, and was constructed for a length of 2,237 feet eastward by May 20, 1875, at which date work thereon was discontinued. Opposition to General Newton's project was manifested, about the time the dike was commenced, on the part of oystermen, on the ground that it interfered with their business. General Newton, however, offered to leave openings in the south dike from space to space to permit the passage of oyster-boats. One opening has already been left for that purpose. The most important opposition to it, however, was manifested by the company engaged in the transportation of freight, in amount about 5,000,000 tons, through the Delaware and Raritan Canal.

These interests procured the passage of resolutions by the New York legislature, January 22, 1875, protesting "against the projected mode of improvement of the Kill von Kull," &c., and requesting "the Senators and Representatives from New York in the Congress of the United States to obtain a modification of the plan of said improvement." Following, and presumably in consequence of, these resolutions, Congress, by section 3 of act approved March 3, 1875, made provision for the appointment of a Board "to examine and report a plan for the improvement of the channel between Staten Island and New Jersey."

Designated by the Secretary of War to perform this duty, and having fully reviewed the subject as above set forth, we are of opinion that General Newton's plan of improvement will secure a channel of sufficient depth across Newark Bay to meet the present and prospective needs of commerce on these waters. We do not, however, recommend that this plan be carried out, for the following reasons:

It is based upon a supposed necessity for creating and maintaining a channel from Elizabethport to Kill von Kull, having a depth at low-water of from 14 to 16 feet. We do not think this necessity now exists, for far the greater part of the freight seeking this channel must be carried in small vessels or barges that navigate the Delaware and Raritan Canal. Of the remaining portion, it is presumed that Elizabethport, the principal shipping and receiving port of the Central Railroad of New Jersey, furnishes the greater part. This road has within a few years formed a new coal-depot at Johnstonville, on the deep waters of the Kill von Kull. Coal-vessels bound eastward, of too great a draught to pass Newark Bay, can load at this new depot, while those bound to southern ports may pass from Elizabethport seaward through Arthur Kill, neither using this channel across Newark Bay. Ordinary freight for the short course from New York, or from points on the Hudson or East Rivers, will not require, and will not probably seek, a large class of vessels for its transportation.

It has been urged that the projected route, by reason of the abrupt transition of direction at the eastern end of the dikes, will inconvenience the towage companies. While the advantages of a wider, deeper, and shorter channel, only about a mile long between dikes, more than compensate for the inconveniences of this change of direction to the larger class of vessels, it is quite probable that large tows would, by

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preference, take the present channel if suitably improved. Any proposition to dike in the present channel would doubtless prove a failure, as the meeting of the Arthur Kill and Kill von Kull currents would form a shoal somewhere between the dikes, or at their entrance, and thus defeat the purpose of their construction. This Board place their decision not to recommend the dike system of improvement already commenced, solely on this ground: that whatever may have been the prospective requirements of commerce on this route three years ago, its present needs do not, in their opinion, call for a 14-foot channel at mean low-water, to be attained by the construction of dikes at large cost. On the contrary, they believe that the existing channel can be sufficiently improved to accommodate present commercial interests, by dredging to a depth of 10 to 11 feet at mean low-water, by diminishing its curvature at the corner stake-light, and by giving it such width as to permit the passage of large tows and the largest class of sailing-vessels in use on these waters, without risk of colliding or grounding. We therefore recommend that this deepening and widening of the channel be effected in accordance with the plan which we now submit.

As the channel, in its western and difficult portion, was produced by the transit of large tows drawn by steamers, and by the larger class of propellers, it is presumed that, when deepened, the same causes will help maintain that depth and diminish the expenditures that will be required from time to time for dredging.

Should the future needs of commerce demand a deeper channel than 11 feet, which we propose to attain by dredging, it is our opinion that recourse must be had to the system of dikes proposed by General Newton. But in that event it would be necessary to make the southern dike continuous, cutting off the passage by the way of Shooter Island, so as to retain the full flow of water between the dikes throughout their lengths.

At the extreme west end of the southern dike a boat-opening should be left, and a boat-channel excavated along the shore to Bridge Creek, as proposed by General Newton, to permit the oystermen to have free access to Staten Island and to the creek for a harbor.

The drawing accompanying this report shows the southern waters of Newark Bay and a portion of Arthur Kill and Kill von Kull, with the soundings, bottom curves, and existing channel-lines.

The channel proposed by this board is marked thereon in strong black lines, about 500 feet apart. The curve of this channel, while conforming to the line of the deepest water, is less abrupt at the corner-stake light than that of the existing channel.

The estimated cost of excavating this channel to a depth of 11 feet and a width of 500 feet is:

ESTIMATE.

Dredging 230,000 cubic yards, at 16 cents	$36,800
Contingencies, 10 per cent	3,680
Total	40,480

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers and Brevet Major-General.
H. G. WRIGHT,
Lieutenant-Colonel of Engineers, Breve Major-General.
J. D. KURTZ,
Lieutenant-Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

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In 1874 the amount of coal deposited at Elizabethport for shipment by vessels was three-fourths of a million of tons, exclusive of other merchandise, as iron-pipe, &c.

Recently, however, the Delaware, Lackawanna and Western Railroad, which had used Elizabethport as one of its termini, has concentrated its deposit of coal at Hoboken. This must materially diminish the importance of Elizabethport as a shipping-point, but whether the loss thus experienced will be compensated from other sources is not definitely known. The position being thus very different from that of the years 1873 and 1874, when the project for a permanent improvement was made and the work commenced, it would seem expedient for the Government to suspend further action in the work of permanent improvement of the channel at Elizabethport until its future prospects shall have a better outlook. As to the improvement of the present channel by dredging, it is evident that it will be temporary only, and must require renewal.

The necessity for this improvement even is not apparent, but 8 feet of draught can be passed through the Delaware and Raritan Canal, while the draught in the present channel at its shoalest point is 9½ feet. The amount of freight through the canal by official statement was in 1871 not 5,000,000 tons, but 3,053,857 tons, and at the present time probably does not much exceed that limit. If, as it is stated, Port Johnston, on Kill von Kull, and situated in deep water, will suffice for the shipment of coal in large vessels, there would appear to be no necessity for such vessels to pass through the channel leading to Elizabethport and recommended to be improved by dredging, which channel does now suffice for the canal-barges, propellers, and small vessels using it to go to Elizabethport or through the canal. If Elizabethport does not emerge from its present state of decadence, additional reasons exist against undertaking any improvement whatever.

To sum up:

1st. In the present condition and prospect of Elizabethport, it would not be expedient to prosecute the works of permanent improvement designed in 1873 and commenced in 1874.

2d. The depth in the present channel being sufficient for the class of vessels using the canal, and for the barges and small class of vessels which, for the future, and until a change for the better, will continue to frequent Elizabethport, no apparent necessity exists for deepening or widening the channel.

3d. No increase in depth or width in the channel can be maintained, except by repetitions of the dredging process.

In conclusion, it is necessary to add that Mr. Francis B. Stevens, of the company engaged in the transportation of freight through the Delaware and Raritan Canal, who wrote a communication to the Chief of Engineers adverse to the project approved by the Government for the permanent improvement, and who expressed a desire to be heard before the Board, although invited to set forth his views and offered every proper facility to this end, has failed to do so, either personally or by representative. Mr. Stevens, owing to his connection with the towing business and to his personal interest therein, would have obtained respectful attention for his views as to the character and nature of the improvements suitable for convenient navigation, as well as to his opposition to the plan of improvements adopted by the Government, and it is to be regretted that such information from a source known to be responsible has not been furnished.

JOHN NEWTON,
Lieut. Col. of Engineers, Brevet Major-General.

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D 10.

IMPROVING HARBOR AT BURLINGTON, VERMONT.

The superstructure of the extension of 145 feet, under contract with Luther Whitney, extending in a northerly direction, has been completed.

Under appropriation of March 3, 1875, under contract with James D. Hancock, the crib-work of an extension of 160 feet, in a northerly direction, has been sunk in position and filled with stone, the superstructure of which has been commenced and will be completed between July 1 and December 31, 1876.

During the month of February, 1876, 220 feet of the southern end of the breakwater was materially injured by a succession of ice-floes coming in contact with it during the prevalence of a terrific northwesterly storm.

This section, consisting of two cribs, each 110 feet in length, was sundered from the main body of the work, in a southerly direction, leaving a clean gap between the two of 26 feet; its northern end is about 7 feet out of line and its southern some 25 feet; the structure is somewhat distorted, stands about 15 inches out of vertical, with its top or surface about 4 feet below its original level.

Burlington Harbor is in the collection-district of Vermont; nearest port of entry, Windmill Point; the nearest fort, Fort Montgomery, New York.

An appropriation of $50,000 is asked.

ESTIMATE.

For 2,000 feet of breakwater-extension in a northwest direction, as recommended in my report for the year ending June 30, 1874	$340,000 00
Amount appropriated	25,000 00

Money statement.

Amount available July 1, 1875	$33,038 33
Amount expended during fiscal year ending June 30, 1876	25,447 62
Amount available July 1, 1876, including $6,480 due on contracts	7,590 71
Amount appropriated by act approved August 14, 1876	20,000 00
Amount (estimated) required for completion of existing project	295,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

D 11.

IMPROVING HARBOR AT SWANTON, VERMONT.

The broken section of the 70-foot crib constructed by Luther Whitney, under the appropriation of June 23, 1874, has been repaired and the superstructure of this extension completed.

Under the appropriation of March 3, 1875, the crib-work of an extension of 69 feet, by contract with James D. Hancock, has been sunk in the line already adopted and filled with stone; the superstructure will be completed between July 1 and December 31, 1876.

Swanton Harbor is in the collection-district of Vermont; the nearest port of entry, Windmill Point; nearest fort, Fort Montgomery, New York.

ORIGINAL ESTIMATE.

1,900 linear feet of breakwater	$272,160 00
Amount appropriated	33,000 00
Amount expended	29,588 15

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Money statement.

Amount available July 1, 1875	$12,843 91
Amount expended during fiscal year ending June 30, 1876	9,432 06
Amount available July 1, 1876, including $2,470.20 due on contracts	3,411 85
Amount appropriated by act approved August 14, 1876	2,000 00
Amount (estimated) required for completion of existing project	237,160 00

Abstract of bids for extension of breakwater at Swanton, Vt., opened June 10, 1875.

Bidders.	Crib complete and sunk in position.	Superstructure complete.	Total.
James D. Hancock	$78 per linear foot	$28 per linear foot	$106 00
James D. Leary	85.95 per linear foot	28.48 per linear foot	114 43
Luther Whitney	90 per linear foot	29 per linear foot	119 00

Abstract of contract for constructing breakwater at Swanton Harbor, Vermont.

Contractor.	Residence.	Date of contract.	Subject of contract.	Remarks.
James D. Hancock	Schenectady, N. Y.	June 26, 1875	69 linear feet of breakwater extension	Crib-work to be completed by December 31, 1875; the superstructure between July 1, 1876, and December 31, 1876.

D 12.

IMPROVING OTTER CREEK, VERMONT.

Under the appropriation of March 3, 1875, under contract with James D. Hancock, dredging operations were commenced on July 1, and continued to August 31, 1875; during this period the work being limited to the improvement of those points of the creek which were found most embarrassing to its navigation, viz:

Along the west shore of the basin a cut 50 feet wide, and of the required depth, has been extended from a point opposite the upper "coal-wharf" to within about 150 feet of the "Horse-nail Factory wharf" at the foot of the falls; the channel opposite the coal-wharf made 30 feet wide; stone and other obstructions cleared away from the face and approaches to the "steamboat-wharf," and the channel at the brick-yard, Sherman's, Gage's, and Crittenden's Bends, Dead Creek, and Fort Cassin Point materially improved.

The amount of materials removed from the various points dredged is 13,000 cubic yards, consisting of silt, stone, clay, gravel, and sunken logs.

The improvements thus far made enable vessels to ascend with their cargoes to within 150 feet of the "Horse-nail Factory wharf."

For completing the improvement of the channel and west side of the basin the amount required will be $43,146.

Vergennes is in the collection-district of Vermont; nearest port of entry, Windmill Point; nearest fort, Fort Montgomery, New York.

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ORIGINAL ESTIMATE.

Dredging, diking, and fascine work	$57,646 00
Removing trees	500 00
	58,146 00
Amount appropriated	15,000 00

Money statement.

Amount available July 1, 1875	$5,086 47
Amount expended during fiscal year ending June 30, 1876	5,022 78
Amount available July 1, 1876	63 69
Amount (estimated) required for completion of existing project	43,146 00

D 13.

EXAMINATION AT ROUSE'S POINT, LAKE CHAMPLAIN, NEW YORK.

UNITED STATES ENGINEER OFFICE,
New York, March 8, 1876.

GENERAL: In obedience to the act approved March 3, 1875, I have respectfully to report upon the examination of Rouse's Point, New York.

This locality was surveyed and examined in the fiscal year 1872–'73, and a report for improvement based thereon was submitted January 20, 1873. This report has been printed, and may be found in the report of the Chief of Engineers for 1873.

No new suggestions for the improvement have suggested themselves.

I transmit herewith copy of the report of Mr. David White, assistant engineer, containing statistics of commerce and navigation of the locality, and a tracing showing results of a partial survey made during the past season.

Very respectfully, your obedient servant,

JOHN NEWTON,
Lieutenant-Colonel of Engineers.

Gen. A. A. HUMPHREYS,
Chief of Engineers.

REPORT OF MR. DAVID WHITE, ASSISTANT ENGINEER.

FORT MONTGOMERY,
Rouse's Point, N. Y., January 26, 1876.

GENERAL: I have the honor to report that, in compliance with your communication of September 2, 1875, I have made an examination of Rouse's Point Harbor, New York.

A series of soundings in parallel lines across the "outlet," and extending from near Stony Point, northward, to the vicinity of the United States boundary-line, have been taken, and the coast-lines at either side of the lake, together with the wharves and other improvements at Rouse's Point, carefully observed; and as a supplement to my report on this harbor made to you January 6, 1873, I would respectfully state, as will be seen by comparing the map of this harbor, herewith sent, with the former, that no material changes have since taken place, save the construction of a small wharf a few rods north of the railroad-bridge, for the accommodation of a large printing and publishing house which has recently been established there.

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The need of a breakwater at this point, and the improvement of the harbor in the interest of local, national, and international commerce, as fully embodied in my former report, remain the same.

It will be remembered this "outlet" lies within the limit of the collection-district of two States, with their respective ports of entry for foreign trade, Rouse's Point and Windmill Point, at either side.

The following summary statements of the foreign trade at this outlet were kindly furnished me by the deputy collectors of customs of the respective ports of entry:

		Tonnage.
Number of vessels entered from Canada in the collection-district of Champlain, New York, Rouse's Point port of entry, during the year ending December 31, 1875	1,311	106,636
Vessels cleared to Canada	1,438	118,378
Vessels cleared coastwise	809	75,684
Total	3,558	300,698

IMPORTS.

Entered for transportation in bond	$745,099 00
Entered for consumption	559,782 33
	1,304,881 33

EXPORTS.

Domestic	$1,151,199 00
Number of vessels enrolled in this district	882
Tonnage	62,047.85
Number of vessels entered and cleared in the district of Vermont, Windmill Point port of entry, from June 30, 1874, to June 30, 1875	1,117
Tonnage	207,119
Cargoes per said vessels was, of lumber, feet	59,743,767
Value of lumber	$832,279 00
Steamers and sail-craft arriving at and departing from Rouse's Point Harbor to home ports from May 1 to November 30, 1875	921
Tonnage	619,181
Freight transshipped at this harbor, as far as rendered, during the above period, tons	35,845

Very respectfully, your obedient servant,

D. WHITE,
Assistant Engineer.

Gen. JOHN NEWTON,
Lieutenant-Colonel Engineers.

D 14.

SURVEY AT PORT HENRY, LAKE CHAMPLAIN, NEW YORK.

UNITED STATES ENGINEER OFFICE,
New York, N. Y., March 29, 1876.

GENERAL: In obedience to the requirements of section 2 of the act approved March 3, 1875, ordering examinations or surveys at "Port Henry, Lake Champlain, for a breakwater," I have to submit the following report. The survey was assigned to Mr David White, assistant engineer, who has submitted, as the results, a chart and report, which are herewith transmitted.

The position and length of the breakwater designed seem to be suitable to afford the protection asked for, the estimated cost being $559,030.

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Port Henry is in the collection-district of Champlain, N. Y.; Rouse's Point the nearest port of entry.

Fort Montgomery, at the outlet of Lake Champlain, is the nearest fort, and the nearest light-house, that on Crown Point.

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. of Engineers, Brevet Major-General.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. DAVID WHITE, ASSISTANT ENGINEER.

FORT MONTGOMERY,
Rouse's Point, N. Y., January 26, 1876.

GENERAL: I have the honor to submit herewith the accompanying map and report of a survey of Port Henry, New York, made in accordance with your directions dated September 2, 1875.

Lake Champlain extends from about 43° 34′ to 45° north latitude, and lies between Vermont and New York, the boundary-line between those States running through its axis; the lake in a right line from north to south is consequently about 100 miles in length, and varies from ¼ to 11½ miles in width; the "Narrow Lake," as it is termed, extending from its southern extremity at Whitehall, northward to "Crown Point," a distance of about 36 miles, and its broader part from this point to its confluence with the Richelieu River, at Rouse's Point.

At Crown Point, by an abrupt receding of the west, or left, shore from the right, the lake increases from 1,400 feet to about 2 miles in width, and thus, by a circuitous sweep of the shore from Crown Point westwardly, together with the railroad embankments and bridge, is formed the bay embracing Port Henry Harbor.

At the foot of this bay, and extending in a northerly direction along the west bank of the lake, lies the harbor-front or series of docks, embracing a low coast-line of about 1¼ miles in length, the shore above and below this rising in high and abrupt bluffs, in many places the rocks rising vertically from the water at the foot of the bluffs and flanking the harbor. On the south lies "Bulwagga Bay," a marsh of about 2 miles in length and of varying width. Bounded by the low coast-line and adjoining the docks is a narrow strip of level land, comprising the piling-grounds, yards, and iron-works of the various mining and manufacturing companies.

From this the surface gradually rises to the west from 450 to 500 feet in height, when it expands into a hilly plateau region, rising into mountains of various heights, distributed over the township of Moriah, of which Port Henry is a part, which mountains are exceedingly rich in minerals. A large number of veins have been opened, containing iron ore in apparently inexhaustible quantities and producing iron of a most excellent quality, all of which is transported by railroad to Port Henry, for both shipment and manufacture, formerly the chief business of the town.

As will be seen by a glance at the map herewith sent, the harbor is naturally well protected on the east and south, but open to north and westerly storms, and it is here, at its lower end, that a breakwater is needed to give to the harbor the additional security it requires.

The harbor has a good anchorage bottom and an ample depth of water, except in the vicinity of that part of it known as "Reynold & Co.'s lumber-yard," where, by the accumulation of silt brought down by Mill Brook, a mere mountain-torrent debouching in at the north side of the basin, the water is too shoal for vessels of the larger class during the lower stages of the lake.

In view of the magnitude of the commerce centering here, as will be seen by the statistics given below, I would respectfully propose that the harbor be given the additional protection it requires by the interposition of a breakwater.

It is proposed to place this breakwater in the position as indicated upon the map, the same to be composed of crib-work 3,500 in length and 30 feet wide, and similar in construction to that at Burlington, Vt., the water along the proposed line having an average depth of 32 feet; the estimated cost of which, including labor, is as follows:

1,066,800 cubic feet of pine timber, at 30 cents	$320,040 00
105,000 feet, (board measure,) pine plank, $25	2,625 00
965,019 pounds drift-bolts, at 4 cents	38,600 76
11,760 pounds of 8-inch spikes, at 5 cents	588 00
124,263 cubic yards of rubble, at $1	124,263 00
Contingencies 15 per cent	72,913 24
Total	$559,030 00

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The following is a summary of the statistics, so far as rendered, of the business of Port Henry, N. Y., for the years 1873, 1874, and 1875, respectively:

1873.

Tons of freight.	Nature of freight.	Number of vessels employed.	Value.
18,816	Iron shipped	198	$714,008 00
328,913	Iron-ore shipped	2,670	2,654,928 13
36,579	Coal received	399	220,335 68
	Cargoes of merchandise and building material received	135	
384,308		3,402	3,589,271 81

1874.

12,544	Iron shipped	132	$385,320 00
181,708	Iron-ore shipped	1,613	1,081,660 64
3,450	Iron-ore received	33	27,600 00
35,645	Coal received	395	230,142 74
	Cargoes of merchandise and building material received	93	
233,347		2,266	1,724,723 38

1875.

13,853	Iron shipped	136	$357,797 00
234,582	Iron-ore shipped	2,028	1,020,012 34
13,486	Iron-ore received	123	62,957 00
37,576	Coal received	378	252,415 48
2,756	Limestone received	25	3,445 00
	Cargoes of merchandise and building materials received	22	
302,253		2,712	1,696,626 82

In addition to the foregoing may be mentioned the regular daily calls made by the passenger-steamers in making their trips between Rouse's Point and Ticonderoga during the season of navigation, for the conveyance of both freight and passengers; likewise those of the tow-boats of the four transportation lines plying between Whitehall and Canada, for the towage of vessels to and from the port.

Very respectfully, your most obedient servant,

D. WHITE,
Assistant Engineer.

Gen. JOHN NEWTON,
Lieut. Col. Corps of Engineers.

D 15.

SURVEY OF ECHO HARBOR, NEW ROCHELLE, NEW YORK.

UNITED STATES ENGINEER OFFICE,
New York, December 20, 1875.

GENERAL: I have respectfully to forward a report upon Echo Harbor, New Rochelle, N. Y., and a chart thereof, in compliance with the provisions of the act of Congress approved March 3, 1875.

Echo Harbor is a well-sheltered expanse of water, being land-locked on all sides except the southeast, where it opens into the Long Island Sound.

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It has a good anchorage-ground, and offers a harbor of refuge for smaller crafts at present.

The bay is easy of approach at all stages of tide, the 18-foot curve of the sound extending into the bay, the depth of water gradually increasing as we advance toward the fair water of the sound.

Echo Bay is 2 nautical miles to the northwest of Execution light, and $2\frac{7}{8}$ miles distant from Sand's light, Cow's Neck.

By water the distance from Echo Bay to Fort Schuyler and fort at Willet's Point is 7 nautical miles, and to the Battery, New York City, 21 miles.

New Rochelle, a thriving city, through which the New York, New Haven and Hartford Railroad passes, lies adjacent to this harbor.

Echo Harbor belongs to the collection-district of New York City, which is also the nearest port of entry.

Mr. A. Doerflinger, assistant engineer, has satisfactorily executed the survey, plotted the greatest part of the field-notes, and gathered valuable information bearing upon the purposes for which the survey was made.

The field-work of the survey was done during the month of July, 1875. Two base-lines were measured, the first along the beach on the southerly shore of the bay, 1,020.10 feet long; the second as a base of verification, along the road running to Beaufort Point, 578.67 feet long. The azimuth of the first base-line was astronomically determined, and its true bearing from station No. 2, from which the observations were made, found to be south 60° 47′ 54″ east; variation of the magnetic needle, 8° 2′ west.

From this base-line a triangulation was extended over the area to be embraced in the survey, and from the trigonometrical points thus determined such other stations as became necessary for the development of the hydrography and topography were located. A tide-gauge was set up at Hudson's dock, Beaufort Point, and carefully leveled into two permanent bench-marks.

In consequence of the small appropriation available for the survey, regular day-observations only were made at this gauge during one lunation; from these observations the following data were deduced: Corrected establishment, $11^h\ 23^m$; mean rise and fall of tides, 7.27 feet; rise of highest tide observed above mean low-water, 8.51 feet; fall of lowest tide below mean low-water, 1.11 feet; mean duration of rise, $6^h\ 14^m$; mean duration of fall, $6^h\ 12^m$; duration of high-water stand, $0^h\ 46^m$; duration of low-water stand, $0^h\ 32^m$.

There is scarcely any current perceptible in the bay, with the exception of that along the westerly shore of Premium Point and Gut Island, during the last quarter of the ebb, due to the tidal discharge of the mill-pond above Premium Point.

The old mill-dam at this point has so contracted the water-way as to prevent a full exchange of tides, thus producing a strong local current.

All the soundings were located by instrumental observations on shore; those to a depth of 18 feet were taken by means of a pole divided into feet and tenths, and those of a greater depth with a line divided into fathoms and feet.

The survey was plotted on a scale of $\frac{1}{2400}$, the detail maps of the obstructions on a scale of $\frac{1}{600}$.

The tidal reductions were carefully made, and the soundings reduced to mean low-water, and introduced on the plot.

The improvement for the benefit of navigation would consist in the removal and marking of certain dangerous rocky obstructions.

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Sheep's-head reef, lying about midway between Echo Island and Duck Point, is a dangerous obstruction, having 1.6 feet of water over its highest point at mean low-water. It lies directly in the path of vessels passing in and out of the bay.

Owing to its distance off shore, and the different aspect of the bay at different stages of the tide, its position is very deceptive, and vessels are very apt to strike it, especially when beating in against a northwest wind.

Start Rock is located about 120 feet off Beaufort Point, directly in the channel.

In consequence of the narrowness of the water-way, this is also a very dangerous obstruction to vessels passing Beaufort Point; its highest point projects 2.2 feet above the plane of mean low-water.

This and Sheep's-head are the two most dangerous obstructions.

Though not relatively so important to navigation, the removal of Long Rock, an obstruction already marked by two iron spindles, would nearly double the width of the channel in front of Beaufort Point. The removal of the 3 rocks above specified would principally benefit the local trade. There being sufficient water-way to the northward of Bailey's Rock, all that would be needed at this point would be the erection of a beacon or spindle on the rock, to indicate its position.

This rock is particularly dangerous to vessels entering the harbor at high-water, as it is then entirely submerged; it projects 3.5 feet above the surface at mean low-water.

All these rocks consist of gneiss, nearly vertically stratified, and running in a northeasterly direction.

After passing Beaufort Point the water shoals up very rapidly, the inner harbor running almost entirely dry at low-water; if this basin was dredged to a depth of about 6 feet at mean low-water, it would afford a very safe anchorage to vessels, and also much facilitate their unloading, although this improvement might properly be left to private enterprise.

ESTIMATE OF COST OF IMPROVING ECHO HARBOR, NEW ROCHELLE, NEW YORK, BY THE REMOVAL OF SHEEPSHEAD ROCK TO A DEPTH OF 9 FEET BELOW MEAN LOW-WATER, AND OF START ROCK TO A DEPTH OF 7 FEET BELOW MEAN LOW-WATER.

Sheepshead Rock, 872.5 cubic yards above the 9-foot curve of 905 square feet area, at $24.30 per cubic yard	$21,201 75
Start Rock, 370 cubic yards, spread over an area of 264 square yards within the 6-foot curve, at $34.25 per cubic yard	12,672 50
Contingencies and engineering, 15 per cent. of the above	5,081 13
Total	38,955 38

The cost for the additional removal of Long Rock to a depth of 6 feet at mean low-water would increase the above sum by $37,696.

The survey and plotting was under the general charge of Mr. Julius H. Striedinger, assistant engineer.

Before closing this report I wish to acknowledge from Capt. A. B. Hudson, of New Rochelle, the receipt of information upon the trade-statistics of the place. (Copy of letter appended.)

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Maj. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

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COMMERCIAL STATISTICS.

NEW ROCHELLE, WESTCHESTER COUNTY, NEW YORK,
December 10, 1875.

DEAR SIR: Your esteemed favor of the 6th instant, asking me for information on certain points bearing upon the contemplated improvement to Echo Bay Harbor in this town, was duly received.

It affords me pleasure to reply thereto, and to give you, so far as I can, the information you desire.

Echo Bay is in the collection-district of New York City. The amount of revenue collected I cannot give, as no record is kept, that I am aware of, which separates the business of this port from that of many other inland ports under the jurisdiction of the customs authorities of New York. New York is also the nearest port of entry.

As to the amount of commerce and navigation to be benefited by the contemplated improvement and the extent to which the general commerce of the country is to be promoted, I can only reply in general terms.

The tonnage of this port for the last three years will amount to upward of 50,000 tons per annum, and the value of the commerce will equal $1,500,000 per annum for the same period.

Fifteen years ago one market-sloop, of about 40 tons burden, making a weekly trip to and from New York, was all the tonnage the port then had. Now as many as 13 vessels have been in the port at one time. Then there was only 69 feet of wharf-frontage, now the harbor has over 1,500 feet of wharf-frontage, well built of stone. The upland comprises one of the finest sections of country to be found around the suburbs of New York City, and this harbor is every year becoming of greater importance as a business section to which the trade of this thickly-settled, large, prosperous, and growing section centers, and it will be apparent to all that the general benefit to be derived from the improvement will be of large and increasing extent.

Echo Bay Harbor has, without exception, the best natural advantages of any harbor on Long Island Sound, and may perhaps compete in these respects with any harbor in the country. With bold water and well landlocked, it offers complete protection in storms to the commerce of Long Island Sound, and were the work completed, it would become a prominent mooring-ground for storm-stayed vessels.

Already the loss of vessels and cargoes on the dangerous reefs which obstruct the entrance to this harbor has exceeded in amount the probable cost of the contemplated improvement.

Believing I have answered your several interrogations, and holding myself in willingness to give you any other information which I may possess,

I am, very respectfully,

A. B. HUDSON.

A. DOERFLINGER, Esq.,
Assistant Engineer.

APPENDIX E.

ANNUAL REPORT OF LIEUTENANT-COLONEL J. D. KURTZ, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., July 13, 1876.

GENERAL: I have the honor to transmit herewith my annual reports of river and harbor works in my charge for the fiscal year ending June 30, 1876.

Very respectfully, your obedient servant,

J. D. KURTZ,
Lieutenant-Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

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E 1.

CONSTRUCTION OF PIER NEAR LEWES, DELAWARE.

During the fiscal year closed June 30, 1876, the pier has been lengthened 126 feet, the substructure now reaching 1,533 feet from the abutment zero, and the superstructure 1,428 from the same point. This difference of length is constant during construction, owing to the lapping of the main girders and the space occupied by the derrick-platform.

Sufficient iron material is now on hand to construct 42 feet more of the substructure.

The inclosed report of Capt. M. R. Brown, Corps of Engineers, gives in detail the operations on this work up to the date of his detachment, October 31, 1875. Since that time only such work as has been necessary for the preservation of the material stored on the grounds has been done.

Should an appropriation be made for the present fiscal year, it is proposed to recommence the work of construction by putting in place the material on hand this season; to advertise for proposals and enter into contracts for 20 piles, with their adjuncts, and to put in place this new material during the present and next season.

The original estimated cost of the pier was	$387,419 67
Which was increased on account of the advance in prices of iron and labor, and the operations of the eight-hour law, by	24,000 00
	411,419 67
Total amount appropriated to June 30, 1876	275,000 00
Total amount expended to June 30, 1876	275,000 00
Amount required to complete the work	136,419 67
On account of decreased price of iron this sum may be decreased by	36,419 67
And the pier can be completed for	100,000 00

Money statement.

Amount available July 1, 1875	$39,293 90
Amount expended during fiscal year ending June 30, 1876	39,218 47
Amount available July 1, 1876	75 43
Amount appropriated by act approved August 14, 1876	30,000 00
Amount (estimated) required for completion of existing project	70,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	70,000 00

REPORT OF CAPTAIN M. R. BROWN, CORPS OF ENGINEERS.

NEW ORLEANS, LA., *March*, 1876.

SIR: I forward herein a report of operations in constructing the United States pier near Lewes, Del., for that portion of the year ending June 30, 1876, during which I was charged with the duty of superintending its construction. On the 30th of June, 1875, the condition of the pier was as follows: Substructure complete to 1,407 feet from the abutment. One-half of the longitudinal stringers extended to 1,365 feet, and one-half to 1,344 feet.

The cross-girders were on and bolted for 1,344 feet, and the scantling was complete to the same line. The decking extended 1,302 feet.

The first pile inserted during the working season of 1875 was placed in position July 10. During July, 5 piles were inserted; during August, 10 piles; in September, 15 piles.

On the 9th of October, 1875, the substructure was complete 1,533 feet, an advance of 126 feet, or 6 bays, made by the insertion of 30 piles and the adjustment of a corresponding number of braces, caps, &c.

One-half the longitudinal stringers extended to 1,470 feet and one-half to 1,449 feet. The framing was complete to 1,428 feet and the decking to 1,407 feet.

A new scow, 35 by 17½ feet, was completed in July, and a new light-raft was built the first week in August.

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Ten piles and other iron material for two bays of the pier arrived on the 8th of August, and it is all now stored on the grounds.

An accurate measurement of the pier on September 28 showed that in a length of 1,512 feet an excess of 3 inches only exists. It is hoped that this small error may be lessened in the future.

A close examination of the expense account on the 9th of October, when I was in Philadelphia on duty, showed that an amount of money remained after all bills should be paid barely sufficient to defray the pay of a watchman and the cost of subsisting the mules for the remainder of the fiscal year. I therefore suspended all labor except that of storing material, by telegraph, and arriving in Lewes again on the 12th of October, I proceeded to place the unfinished end of the pier, the derrick, &c., in a proper condition to secure them against accidents, to be anticipated from the pressure of ice and the winter storms. The labor of 3 or 4 men in 2 weeks was sufficient to accomplish this result, and on the 1st of November the overseer, who had been engaged at a reduced rate as "property-keeper," was the only employé under pay.

The building of a fog-signal station on Cape Henlopen, calling for means of transportation for the material used in its construction, afforded a chance to employ the mules during the early winter so that they should earn a portion of the cost of keeping them during the period of suspension of work on the pier.

The methods of construction during the year have not varied essentially from those employed hitherto. The workmen employed were picked from those who had had in previous years a considerable amount of experience in this novel and peculiar construction, and the progress made was all that could be expected. Considerable but unavoidable delays occurred at times from the want of material, and the weather was on the whole unfavorable for rapid progress.

The iron material for 6 bays, or 126 feet, in addition to that now on hand, is lacking to complete the pier itself to 1,701 feet, its projected end, besides all the material of the fender system, &c. About 8,000 feet of lumber, or 20 pieces $4'' \times 9'' \times 42'$ and $3'' \times 6'' \times 26'$, must be purchased to supply the place of that used in auxiliary constructions, and to replace a few sticks which have deteriorated from contact with sand, which has banked up around the lumber-piles.

Great care has been taken to protect the lumber from this source of decay, and it is a matter of congratulation that so little has been lost, in a locality where the surface is composed wholly of shifting sand, controllable only by great watchfulness and an expenditure of considerable labor.

On the 31st of October I received a copy of Special Order No. 218, War Department, Adjutant-General's Office, ordering me to proceed to Detroit and report to Maj. C. B. Comstock for duty on the improvement of South Pass, Mississippi River, and afterward to take station in New Orleans. I left Lewes for that purpose November 14.

This report brings my present connection with Lewes pier to a close.

Very respectfully, your obedient servant,

M. R. BROWN,
Captain of Engineers, U. S. A.

Lieut. Col. J. D. KURTZ,
Corps of Engineers, U. S. A.

E 2.

IMPROVING ICE HARBOR AT NEW CASTLE, DELAWARE.

The construction of a crib for the foundation of a new ice-pier, on the lower line of the harbor, had been commenced at the close of the last fiscal year. This work was continued, and by September the crib had been sunk in place and the stone superstructure commenced. The pier was entirely completed in November.

During the summer the end of the coal-wharf, below the piers, was removed for a distance of 108 linear feet from the head. The effect of this partial removal has been to allow a strong current on the flood-tide, which before was thrown entirely outside the ice-harbor, to pass now inside of the new pier. About 130 linear feet of the coal-wharf remain to be removed to bring it to the solid wharf-line established by the town commissioners.

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Should a small appropriation be made for the present fiscal year, it is proposed to complete the removal of this wharf to the commissioners' line.

Next year it is proposed to construct another ice-pier at this harbor, and to dredge out the accumulated sediment, for which purpose an appropriation of $28,500 is asked.

Money statement.

Amount available July 1, 1875	$34,043 70
Amount expended during fiscal year ending June 30, 1876	30,949 30
Amount available July 1, 1876	3,094 40
Amount appropriated by act approved August 14, 1876	12,000 00
Amount (estimated) required for completion of existing project	28,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	28,500 00

E 3.

IMPROVING HARBOR AT WILMINGTON, DELAWARE.

By the act of March 3, 1875, $10,000 was appropriated "for the improvement of the harbor at Wilmington, Del." Work under this appropriation has been carried forward during the fiscal year ending June 30, 1876, at the several localities in the harbor enumerated below, viz, just below the buoy-depot of the light-house establishment, near the entrance to the river, along the south slope of channel just below, and along the north side of channel above Third-street bridge, and along the north side of the channel above Market-street bridge. The material removed just below Third street was about 105 cubic yards of fast rock, the work being done by the American Dredging Company of Philadelphia, under contract dated May 28, 1875. The character and amount of material removed from the remaining localities where the work of improvement has been going on during the year are as follows, viz: From the south side of the channel below the buoy-depot of light-house establishment, 12,000 cubic yards of soft mud; from the north side of channel, above and in the immediate vicinity of Third-street bridge, 14,007 cubic yards of mud; from the north side of the channel above Market-street bridge, 4,070 cubic yards of coarse gravel. This work was performed under a contract with William H. Beard, of Brooklyn, N. Y., executed May 28, 1875. Operations for the removal of fast rock mentioned above commenced June 1, 1875, and were completed on the 5th of August, 1875. For the removal of the mud and gravel, work commenced November 15, 1875, and continued until December 18, 1875, when operations for the winter were suspended. The work was resumed February 10, 1876, and continued to completion under the contract on the 31st of March, 1876.

The results of the work for the improvement of this harbor for the past year are an increase of width to the channel at the entrance to the harbor to 300 feet for a distance of about 600 feet; an increase in width to the channel just above Third street to 150 feet, for a distance of about 600 feet; an increase in width of the channel just above Market street to 150 feet, for a distance of about 600 feet; in each case affording 12 feet depth of water at ordinary low-tide, and at the fast-rock excavation just below Third street the depth has been made 13 feet at ordinary low-tide.

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With a further appropriation, it is proposed to continue the improvement of the harbor during the present working season by the removal of about 1,400 cubic yards of mud from the channel opposite and just below the mouth of Brandywine Creek; 4,000 cubic yards of mud from a point protruding into the channel just above Brandywine Creek; 210 cubic yards of fast rock from the south slope of channel just below Third street, (which will complete the improvement of that locality;) and about 3,000 cubic yards of mud from the south side of channel above Market street.

Next season it is proposed to continue the improvement of the harbor by the removal of about 30,000 cubic yards of mud from the channel between the mouth of the Brandywine Creek and the Christiana Iron Company's pier, and about 40,000 cubic yards of mud from the channel of the river just above the buoy-depot of the light-house establishment.

This work will require an appropriation of $20,000.

Wilmington is in the collection-district of Delaware, and is a port of entry. The nearest light-house and fort are, respectively, Christiana light and Fort Delaware. The amount of revenue collected at Wilmington during the fiscal year ending June 30, 1876, is $14,641, and at Philadelphia, $8,281,420.

ORIGINAL ESTIMATE FOR IMPROVING WILMINGTON HARBOR, DELAWARE.

1. For removal of a rock in channel-way, as specified in report of November 2, 1870	$1,000 00
2. For dredging a cut 120 feet wide, 12 feet deep at low water, through the bar at the mouth of the river, 19,000 cubic yards, at 40 cents	7,600 00
3. For dredging a cut 120 feet wide, 12 feet deep, through the shoal just below the Brandywine, 32,000 cubic yards, at 40 cents	12,800 00
4. For dredging a cut 120 feet wide, 12 feet deep, above the Brandywine to the ship-yards, 4,800 cubic yards, at 40 cents	19,200 00
5. For widening the cut at the light-house to 300 feet, 96,000 cubic yards, at 40 cents	38,400 00
Add for surveys, inspectors, office-expense, and contingencies	4,000 00
Total	83,000 00
Total amount appropriated to June 30, 1876	$47,000 00
Total amount expended to June 30, 1876	46,879 71

Money statement.

Amount available July 1, 1875	$10,129 34
Amount expended during fiscal year ending June 30, 1876	10,009 05
Amount available July 1, 1876	120 29
Amount appropriated by act approved August 14, 1876	16,000 00
Amount (estimated) required for completion of existing project	20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	20,000 00

E 4.

IMPROVING HARBOR AT MARCUS HOOK, PENNSYLVANIA.

During the fiscal year ending June 30, 1876, important repairs were made to the lower outer ice-pier at this harbor. It was seriously injured by the large iron steamship which came into collision with it, as was stated in my last annual report.

The commencement of the repairs was delayed, so that they were not completed until the 24th of December. The original estimate for these repairs was $1,650, but upon removing the stone backing of super-

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structure, and timber and stone filling of the substructure, preparatory to going forward with the work, it was found that the injury to the pier caused by the steamship was more extended than was apparent upon the examination made at first. The side and upper salient faces of the crib, and also the upper timber-platform, were badly cut away, and it was with considerable difficulty that the new timber was fitted and placed in position, securely bolted, and made complete to receive the stone superstructure. The cost of repairing this injury was finally $2,509.

It is proposed to examine these piers with a view to ascertain whether the currents have cut away the bottom of the river around their bases. This was found to be the case with the one referred to above, and which has been provided with an enrockment, and this treatment may be advisable for the others.

Money statement.

Amount available July 1, 1875	$9,497 53
Amount expended during fiscal year ending June 30, 1876	2,795 62
Amount available July 1, 1876	6,701 91

E 5.

IMPROVING HARBOR AT CHESTER, PENNSYLVANIA.

There being no appropriation available for this harbor, no work was done on the Government piers during the fiscal year ending June 30, 1876.

The last expenditure of funds at this harbor was made in 1873, in renewing the two connecting bridges at the upper piers. The cap-logs to piers and wharves, and two or more courses of timber below them, require renewing; the bridge at the lower pier is about worn out, and those at the upper piers require minor repairs, together with the earth and stone causeway leading from the lower pier back to the fast land.

In my last annual report it was recommended that the sum of $6,000 be appropriated for the purpose of these repairs. Should Congress make the appropriation asked for, it is proposed to commence and complete these repairs during the present season.

Chester continues to retain its prominence as a ship-building point and for manufacturing industries. It is in the collection-district of Philadelphia. The nearest port of entry, light-house, and fort, are, respectively, Philadelphia, Fort Mifflin light, and Fort Mifflin. The amount of revenue collected at Philadelphia during the fiscal year ending June 30, 1876, was $8,281,420.

Money statement.

Amount appropriated by act approved August 14, 1876	$2,600
Amount (estimated) required for completion of existing project	3,400
Amount that can be profitably expended in fiscal year ending June 30, 1878	3,400

E 6.

IMPROVING SCHUYLKILL RIVER, PENNSYLVANIA.

During the fiscal year ending June 30, 1876, operations for the improvement of this river have included the removal of 4,656 cubic yards

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of mud from the mouth; 3,175 cubic yards of mud from the channel near Girard Point; 10,236 cubic yards of gravel from the channel above, and adjacent to Penrose Ferry bridge, and 28,190 cubic yards of coarse gravel and bowlders from the channel near Gibson's Point.

The effect of the excavation at the mouth was the removal of a few shoal points along the axis of the channel between the Delaware and a point about 1,000 feet up stream; near Girard Point a narrow shoal strip along the north side of the channel was removed; and above, and adjacent to Penrose Ferry bridge, a continuation of the excavation through the bar was made, nearly completing the improvement at that point. The work near Gibson's Point was making a cut 25 feet in width along the western slope of the channel for a distance of 1,000 feet, and a cut 50 feet in width for a distance of 1,250 feet in length. In all cases the depth of water effected was 20 feet at ordinary low-tide.

With the exception of a short distance through the cut at the bar just below "Penrose," the result, on the whole, is an uninterrupted channel-way with 20 feet depth of water at low-tide, and not less than 150 feet in width from the mouth of the river to near Gibson's Point, a distance of 4¼ miles.

As evidence of the importance of the improvement of the Schuylkill River, which has been in progress by the United States since 1870, it is of interest to state that in the single item of grain there have been shipped to foreign ports from this river 10,813,429 bushels during the past fiscal year.

Since the commencement of the improvement of this river, in the fall of 1870, there have been removed from the channel-way 366,813 cubic yards of material, distributed as follows: From the mouth of the river and immediate vicinity, 51,649 cubic yards of mud; from Girard Point, 10,071 cubic yards of mud; from the bar above Penrose Ferry bridge, 216,113 cubic yards of gravel; from near Gibson's Point, 88,078 cubic yards of coarse gravel and bowlders; from off South street, 172, and from off Locust street, 730, cubic yards of fast rock.

As recommended in my last annual report, it is proposed to modify the project for the improvement of this river by enlarging the cut from the Delaware into the Schuylkill, until it shall have a width of 300 feet and a depth of 24 feet at low-water. To form this enlarged entrance cut will require the removal of 300,000 cubic yards of material by dredging, at a cost of about $75,000. This is rendered necessary by the greatly-enlarged business and increased size of vessels loading at the grain-elevator at Girard Point. No other change is proposed to be made in the work.

If an appropriation is made for continuing the improvement of this river during the present season, it is proposed to remove by dredging at the mouth of the river a probable small deposit made by the ebb-currents of the two rivers from above during the past year; remove about 3,000 cubic yards of gravel from the east side of the cut through the bar above Penrose Ferry bridge, completing the work at that point; 18,000 cubic yards of coarse gravel and small bowlders, and 150 cubic yards of fast and loose rock, from the channel near Gibson's Point; and 8,000 cubic yards from the channel between Gibson's Point and Gray's Ferry bridge. The last-mentioned work to be with a view of affording 18 feet depth of water in the channel above Gibson's.

It is proposed to continue the improvement of the river during the next fiscal year by removing from the channel between the mouth and Girard Point, (with a view of obtaining ultimately 24 feet at low-tide,) 140,000 cubic yards of mud; from the channel off Gibson's Point, about 150

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ubic yards of rock, and above Gibson's about 40,000 cubic yards of and and loose material.

Original estimated cost of improvement	$257,700
Increase of 1874, ($40 per yard for rock instead of $25)	42,000
Increase as recommended in this report for additional depth and width at the mouth of the river	75,000
	374,700
Total amount appropriated and expended	145,000

This work is in the collection-district and port of Philadelphia. The nearest light-house is Fort Mifflin light. The nearest fort is Fort Mifflin. The amount of revenue collected at Philadelphia during the fiscal year ending June 30, 1876, was $8,281,420.

Inclosed herewith is a statement of the grain and oil trade done during the year ending June 30, 1876, in the Schuylkill River.

Money statement.

Amount available July 1, 1875	$19,759 34
Amount expended during fiscal year ending June 30, 1876	19,659 49
Amount available July 1, 1876	99 85
Amount appropriated by act approved August 14, 1876	20,000 00
Amount (estimated) required for completion of existing project	209,700 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	60,000 00

STATEMENT OF THE BUSINESS DONE AT GIRARD POINT ELEVATOR FROM JULY 1, 1875 TO JUNE 30, 1876.

OFFICE OF PETER WRIGHT & SONS, GENERAL AGENTS,
307 *Walnut Street, Philadelphia, July* 12, 1876.

Received 25,856 cars, containing 11,052,072.28 bushels of grain.

Shipped on board 361 vessels 10,813,429.24 bushels of grain.

The total grain business of Philadelphia in six months, January 1 to July 1, 1876, amounted to 11,042,554 bushels; January 1 to July 1, 1875, amounted to 3,921,624 bushels.

The oil business at Point Breeze from July 1, 1875, to June 30, 1876, inclusive, has employed a total of 419 vessels, and that of Gibson's Point 90 vessels of all classes.

We inclose herewith a slip showing the present condition of the improvements at Girard Point.

Yours, very truly,

PETER WRIGHT & SONS.

IMPROVEMENTS AT GIRARD POINT.

The International Navigation Company, (Red Star Line,) of which Messrs. Peter Wright & Sons are managers, are making extensive improvements on their property at Girard Point, at the month of the Schuylkill, to accommodate their rapidly increasing business. They have just completed two additional piers, each 500 feet long by 60 feet wide, which, with those already built, will give dock-room for forty large ships. On one of the piers they are about erecting a large iron transfer-elevator, with a capacity for unloading about 100 car-loads of grain a day, and transferring it direct to the hold of vessels in the docks. This, in addition to their immense storage-elevator, completed last year, gives them one of the finest systems of elevators in the world.

There are also being laid three additional miles of steel railroad-track in their yard and piers. The track is laid in the best manner, ballasted with stone, and, when completed, will give standing-room for 500 cars.

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E 7.

IMPROVING DELAWARE RIVER AT FORT MIFFLIN BAR.

During the fiscal year ending June 30, 1876, operations for this improvement have been in progress along the western portion of the proposed improvement, excavating a channel through the bar from the New Jersey channel south to the Pennsylvania channel on the north, affording 22 feet depth of water at ordinary low-tide. The work has been executed by contracts made under the appropriations of June 23, 1874, and March 3, 1875. Operations in dredging under the first contract ceased August 7, 1875, when the work was continued under the second to April 5, 1876, when operations ceased under these appropriations.

One hundred and twenty-five thousand and sixteen cubic yards of material have been removed from the bar, under the two contracts.

The improvement was then continued as reported here below under the law for "Improving the Delaware River between Petty's Island and its mouth."

Money statement.

Amount available July 1, 1875	$39,959 89
Amount expended during fiscal year ending June 30, 1876	39,095 89

E 8.

IMPROVING DELAWARE RIVER, BETWEEN PETTY'S ISLAND AND ITS MOUTH

The balance of the appropriation for improving the Delaware River at Horseshoe Shoals, $49,500, was transferred by the act of March 3, 1875, to this improvement, as reported last year.

Operations under this appropriation, so transferred, have been carried on, in conformity with the approval of the Chief of Engineers, at the several localities along the river-channel enumerated below, viz:

Fort Mifflin Bar near Fort Mifflin, Bulkhead Shoals near Fort Delaware, and in the main ship-channel below Reedy Island.

Work was commenced at Fort Mifflin Bar about April 1, 1876, under contract executed July 22 of last year, and continued to June 13, 1876, when operations ceased, owing to the exhaustion of funds.

The plan of operations was a continuation of the excavation through the bar from the channel on the south to the channel on the north, affording 22 feet depth of water at low-tide, commencing at the point on the western line of the improvement where operations ceased under the contract of May 22, 1875, made under the specific appropriation for the improvement of Fort Mifflin Bar by act of March 3, 1875. Under this contract, 96,221 cubic yards of material were removed, making a cut about 2,500 feet in length, with a width of 200 feet.

The excavation through the bar under this appropriation, and in connection with that made under the specific appropriations for this improvement, has been in progress during the several working seasons since 1873, dredging a deep-water channel across the bar, with a width of about 1,200 feet.

The excavation for this channel through the bar has fallen short of the width designed, owing to large recent accumulations of mud at the extremities of the cuts, which did not form a part of the material to be removed in the original estimate. These unexpected deposits of mud,

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amounting to 105,000 cubic yards, which have probably come down the river from dredged material deposited on the Light-House Shoal, 2½ miles above the work, had to be removed.

During the whole period of this improvement, which commenced in July, 1873, and was suspended June 13, 1876, 623,195 cubic yards of material have been removed, forming a cut about 2,500 feet in length, about 1,200 feet in width, and about 22 feet depth of water at ordinary low-tide.

The improvement at Bulkhead Shoals consists in deepening and straightening the channel, by cutting away the shoal points projecting into it on either side to a minimum depth of 21 feet at mean low-water.

Under a contract awarded at the close of the last fiscal year, the work of dredging was commenced July 22, 1875, on the point of a shoal on the lower side of the channel at the bend, and continued until November 5, resulting in the removal of 97,972 cubic yards of sand and mud.

The extent of the excavation was about 2,800 feet in length by 250 feet in width, and the cut averaged about 3½ feet in depth.

A wreck of an oyster-schooner lying in the main ship-channel, about 3 miles below Reedy Island light, which formed a dangerous obstruction to navigation, was removed under an agreement with the American Dredging Company, at a cost of $900.

If an appropriation is made for continuing these improvements, it is proposed during the present season to remove the deposits of mud which have taken place during the year in the cut through Fort Mifflin Bar, and in the New Jersey channel just below it, and to continue the work of dredging at Bulkhead Shoals by cutting away a projecting point of it on the northern and western side of the channel.

Money statement.

Amount available July 1, 1875	$49,075 55
Amount expended during fiscal year ending 30, 1876	49,075 55
Amount appropriated by act approved August 14, 1876	40,000 00
Amount (estimated) required for completion of existing project	235,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	100,000 00

E 9.

IMPROVING DELAWARE RIVER BETWEEN TRENTON AND WHITE HILL, NEW JERSEY.

At the close of operations in the fall of 1875, a dredged channel, with a width of 125 feet at its narrowest point and a depth of 6 feet at low-water, had been formed around Periwig Island. The appropriation of $10,000, made by act of March 3, 1875, was applied to the removal by dredging of such obstructions of gravel and bowlders as were caused by the action of freshets and the ice of winter, and to increasing the width of the channel at its upper end to 150 feet.

If an appropriation be made for the service of the present fiscal year, it will be expended in improving the channel around Periwig—in maintaining its depth and increasing its width.

An appropriation of $10,000 for the next fiscal year is asked for continuing the improvement of the river between Trenton and White Hill.

Trenton is in the collection-district of Burlington; Philadelphia being the nearest port of entry. The nearest light-house and fort are, respectively, Fort Mifflin light and Fort Mifflin. The revenue collected at Philadelphia during the year ending June 30, 1876, amounted to $8,281,420.

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ORIGINAL ESTIMATED COST OF WORK.

To excavate a cut through the shoal at Periwig Island, 200 feet wide and 6 feet deep, will require the removal of 140,000 cubic yards of gravel, bowlders, &c., at 50 cents	$70 000
Below Newbold's Island, a cut 200 feet wide, 700 feet long, and 1 foot deep, 5,000 cubic yards, at 40 cents	2,000
Contingencies	3,000
Total	75,000
Total amount appropriated to June 30, 1876	45,000
Total amount expended to June 30, 1876	45,000

Money statement.

Amount available July 1, 1875	$10,000 00
Amount expended during fiscal year ending June 30, 1876	10,000 00
Amount (estimated) required for completion of existing project	30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	10,000 00

E 10.

IMPROVING BROADKILN RIVER, DELAWARE.

No work has been done on this improvement since the spring of 1874, when the appropriation of $10,000 was exhausted.

Should further appropriation be made by Congress, it is proposed to continue the original project for the improvement by dredging the river at the shoal places, and by opening an inlet into the bay at the junction of Broadkiln and Lewes Creeks.

ORIGINAL ESTIMATED COST OF THE WORK.

For making an opening across beach to discharge waters of Broadkiln and Lewes Creeks into bay	$14,790
For dredging the Broadkiln River and building dam to turn the waters from Lewes Sound to New Inlet	65,657
Total cost of improvement	80,447
Amount appropriated since adoption of project	$10,000
Amount expended since adoption of project	10,000

This work is in the collection-district of Wilmington, Del., which city is the nearest port of entry. Fort Delaware is the nearest fort, and Delaware Breakwater light is the nearest light-house.

Amount (estimated) required for completion of existing project	$60,447
Amount required for fiscal year ending June 30, 1878	10,000

Money statement.

Amount (estimated) required for completion of existing project	$60,447 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	10,000 00

E 11.

IMPROVING THE NORTH AND SOUTH BRANCHES OF THE SHREWSBURY RIVER, NEW JERSEY.

No appropriation was made for the improvement of this river for the last fiscal year. The allotment made for a survey of this river, in part,

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was expended in surveys made at the mouth of the river and at Upper and Lower Rocky Points, and a project for the improvement of the river at Upper and Lower Rocky Points has been submitted.

If an appropriation be made for the service of the present fiscal year, it will be applied in dredging at Upper Rocky Point.

An appropriation for the next fiscal year of $13,000, in accordance with the project, is asked, for continuing and completing the improvement at Upper and Lower Rocky Points.

Shrewsbury River is in the collection district of Amboy; fort at Sandy Hook is the nearest fort, and Navesink lights are the nearest light-houses.

ESTIMATE OF THE COST OF IMPROVEMENT OF THE RIVER AT UPPER AND LOWER ROCKY POINTS.

Close-pile structure, 1,200 feet long, at Lower Rocky Point		$9,000
Dredging at Upper Rocky Point	$4,800	
Dredging at Lower Rocky Point	3,200	
Contingencies	1,000	
		9,000
Total		18,000

During the years 1872–'74, $19,000 were expended in dredging at various points on this river. Since then several changes in the channel have occurred, and a survey of the river at three of these points has enabled a project to be made with an estimate of cost.

Total amount appropriated to June 30, 1876	$19,000
Total amount expended to June 30, 1876	19,000
Amount required for the fiscal year ending June 30, 1878	13,000

E 12.

IMPROVING COHANSEY CREEK, NEW JERSEY.

This improvement remains in an incomplete condition, no appropriation having been made for the last two fiscal years. An appropriation of $10,000 is asked for continuing the improvement in accordance with the project submitted December 9, 1872.

ORIGINAL ESTIMATE OF COST.

Sixty-seven thousand nine hundred and eighty-eight cubic yards of dredging, at 37 cents		$25,155 56
Inspector		750 00
Advertising and office-work		400 00
Laying out and supervising work		500 00
Contingencies		3,194 44
		30,000 00
Total amount appropriated to June 30, 1876		10,000 00
Total amount expended to June 30, 1876		10,000 00

Cohansey Creek is in the collection-district of Bridgeton, N. J., which is the nearest port of entry. Fort Delaware is the nearest fort, and Cohansey light is the nearest light-house.

Amount (estimated) required for completion of existing project	$20,000
Amount required for fiscal year ending June 30, 1878	10,000

Money statement.

Amount (estimated) required for completion of existing project	$20,000
Amount that can be profitably expended in fiscal year ending June 30, 1878	10,000

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E 13.

DELAWARE BREAKWATER HARBOR.

During the fiscal year ending June 30, 1876, nothing has been done to this work by the United States.

In the early part of the year, the Western Union Telegraph Company, by permission of the Hon. Secretary of War, occupied the old light-house building on the breakwater as a telegraph station. Poles were placed along the work, and wires run, and connection with the main line on shore made by means of a cable laid from the southeastern extremity of the breakwater to a point on Cape Henlopen, about 1,800 feet inside of the beacon light.

Appended hereto is a table showing the number of vessels seeking refuge in the harbor for 12 years past, between 1833 and 1876:

Statement of vessels taking refuge in Delaware Breakwater Harbor during the years stated below.

Year.	Ships.	Barks.	Brigs.	Schooners.	Sloops.	Pilot-boats.	Steamers.	Total.	Remarks.
1833	22	.....	178	372	167	127	.....	866	
1838	165	.....	732	3,191	765	685	.....	5,538	
1842	107	.....	1,060	5,335	802	794	.....	8,098	
1847	342	.....	1,937	7,742	358	874	.....	11,253	
1854	35	247	1,085	5,098	90	.....	114	6,669	
1862	55	239	879	8,087	253	.....	246	9,759	
1867	113	290	825	8,000	307	.....	279	9,814	
1872	119	639	1,008	8,588	522	923	629	12,428	
1873	192	877	867	13,976	734	.....	844	17,490	Pilot-boats classed with schooners.
1874	166	605	623	9,797	477	.....	781	12,449	
1875	222	804	581	9,527	420	.....	843	12,397	
From Jan. 1, 1876, to July 1, 1876.	129	1,115	243	4,741	242	.....	428	6,898	Six months' return.
Total for 36½ years	5,817	9,347	31,892	222,456	16,624	13,688	8,569	308,393	

E 14.

SURVEY OF NORTH AND SOUTH BRANCHES OF SHREWSBURY RIVER, NEW JERSEY.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., February 1, 1876.

GENERAL: I have the honor to present the following report of the survey of the "north and south branches of the Shrewsbury River, New Jersey," provided for in the river and harbor act of 1875, (general nature, No. 33,) approved March 3, 1875, and committed to me by your instructions of March 22, 1875:

The field-work of this survey was executed in August and part of September, 1875, and the office-work has been in progress during the interval since, as other duties permitted it to be worked upon.

The charts, marked 1 and 2, which accompany this report, show the results of the survey and the remedial measures which it is proposed to adopt for the improvement of the navigation of the waters concerned. It will be seen that somewhat more work has been accomplished upon the survey than was anticipated with the amount of funds that could be assigned for it from the general appropriation for surveys.

The improvements of the navigation of the Shrewsbury Rivers which

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were executed during the years 1871–'72–'73, were based upon the information obtained by inquiry among the navigators and pilots familiar with the waters, and such examinations as it was practicable to make from time to time during the progress of the work.

In 1874 it was stated in my annual report that a careful survey should be made before further work upon the improvement of this river. This statement was caused by two reasons: one, that no survey could be found on record giving any suitable information for comparison upon the points involved; the other, that the changes in the condition of the waters had been extraordinary and extreme, having been caused by the repeated breaching of the ocean-beach by storms and corresponding succeeding closures of these inlets by the action of the river-currents. Thus, at one time, 1779–'82, the discharge of the rivers was direct into the ocean, at a point near the junction of the North and South branches; at another, 1836, this inlet had crept up the beach abreast of and beyond the position of the Navesink lights; and again, 1850, the beach had become continuous to Sandy Hook Bay. Sometimes again, as in 1844, two inlets existed through the ocean-beach, while at the same time a water-way opened into Sandy Hook Bay; and again this water-way was entirely closed by a bar rising above high-water level, and extending across from the Navesink shore to the Sandy Hook beach. These particulars are illustrated in the small sketches on chart 3.

These circumstances are so variant that no expectation could be entertained of any control of the waters until the ocean-beach should first be maintained in a permanent stable condition for some time, and then the enormous quantities of sand accumulated by the breaches be removed from the passage-way of the rivers, and the rivers be thoroughly established in their normal channels, undisturbed by inroads from the ocean.

About 1865 the New Jersey Southern Railroad was built from Spermaceti Cove along the front beach to Long Branch, and this construction gave promise that the beach would be permanently protected from breaches by the ocean. This first condition has been maintained steadily since that time, so that it now remains only to remove the vast sand deposits and shoals which were produced during the previous disturbed condition of the rivers. The ebb and flood tides of the rivers are steadily at work reducing these obstacles to the regular flow of the waters; their influence is without cost, and is far more potential than any artificial means that can be applied within the limits of moderate cost or expenditure.

In 1871 our operations for improving the depth of water in shoal places were begun.

A channel was excavated by dredging at the junction point of the two rivers, (Lower Rocky Point,) so as to increase the depth of water at that locality from 2 feet to 6 feet at low tide. Another excavation was made at Upper Rocky Point, about 1,200 yards up the North Shrewsbury, so as to connect the deep water above and below, and afford a continuous navigation at low tide for draughts of 6 feet. A third cut was made a little within the entrance to Sandy Hook Bay, affording the same depth of water. These and some minor excavations were made during the seasons of 1871–'72–'73. Great need was felt of more definite information than could be obtained respecting both the condition of the river and its history in past years, and it was recommended, as stated above, that a survey should precede further expenditure for improvements. This survey has now been executed. Unfortunately there is no previous survey suitable for the purpose of comparison. It will be seen, however, by examination of the charts, that the work at

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Lower Rocky Point has been as successful as could be looked for in view of the remarkable irregularities of the bottom at that locality. It is proposed to place along the line of the channel there leading up the North Branch, a deflector of pile-work, so arranged as to control the currents, both of flood and ebb, while not disturbing the waters of South Shrewsbury, either entering or ebbing.

When this deflector is built, it is believed that very little dredging will be required in front of it, to afford a channel of regular and uniform section around Lower Rocky Point.

At Upper Rocky Point, the survey shows that the artificial cut which has been made should be connected with the southern loop of deep water, as well as with the northern one, and the flow of water be thus encouraged to take the southern channel above this point.

The work at the mouth, or near Sandy Hook Bay, has not resulted so well. It appears there that the discharge-channel is in a condition of transition; that the deep water west of the "Island Beach" Island, and the loop from Sandy Hook Bay corresponding to it, are not likely to be permanent features of the river, but that they have occurred as the river is slowly returning to a channel of discharge which follows the inner line of the ocean-beach, and may eventually find its outlet at or near the *Point of Cove.*

The portion of Shrewsbury River affected by the breaches from the ocean extends from Sandy Hook Bay to above Upper Rocky Point, a length of 6,000 or 7,000 yards, besides the disturbances in South Shrewsbury from the junction up. These disturbances have been on a vast scale, involving the transposition of enormous amounts of sandy deposits. That portion of the river from Lower Rocky Point up, will be the first to resume a regular regimen; and artificial works to aid in this result may be first applied, and be expected to prove most effective there. At the mouth of the river, the natural forces at work must produce their effects more gradually, and it will be wiser to wait until the state of equilibrium is near at hand, instead of now interposing the efforts, comparatively small, which our limited means enable us to bring into play.

It may eventuate that little or no assistance will be found necessary to promote the formation of a good channel in this portion of the river.

The channel between Lower Rocky Point and the Island Beach Island is now good, and has been so for some years past. It passes from above, along the mainland or west shore, past the Highlands wharf, and then obliquely over to the beach-shore. At the same time the ebb-current at Rocky Point has some tendency to shoot over to and down along the beach. It will be seen by the chart that the cause of these peculiarities is a great deposit of sand, (1,000 yards long at low water in 1844,) the effect of a breach at the locality. This shoal has now nearly disappeared at low-water, and the material washed from it by the flood-tide must be a principal cause of disturbance in the waters about Lower Rocky Point, and probably also yields material which shoals the waters of the South Shrewsbury. When it is all removed by the currents, then the channel may establish itself on the beach-side along the whole length of the united river.

ESTIMATE FOR A CLOSE PILE STRUCTURE ABOUT 1,200 FEET LONG—PILES ABOUT 12″ DIAMETER, PLACED SIDE BY SIDE, WITH GUARD-TIMBERS ALONG THE SIDES, BOLTED ON THE PILES NEAR HIGH-WATER MARK.

20′ hemlock piles—970 piles in place, at $5	$4,850
Guard-timbers, 30,000 feet, board-measure, at $50	1,500
Bolts, workmanship, &c	1,000

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Superintendence		$400
Contingencies		1,250
		9,000
Dredging at Upper Rocky Point, 15,000 cubic yards sand, at 32 cents..	$4,800	
Dredging at Lower Rocky Point, 10,000 cubic yards sand, at 32 cents..	3,200	
Contingencies	1,000	
		9,000
Total		18,000

Very respectfully, your obedient servant,

J. D. KURTZ,
Lieut. Col. of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX F.

ANNUAL REPORT OF MAJOR WM. P. CRAIGHILL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., July 12, 1876.

GENERAL: I have the honor to forward herewith the annual report for the year ending June 30, 1876, for works of improvement of rivers and harbors, and of examinations and surveys in connection therewith, which have been in my charge.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers, Brevet Lieut. Col., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

F 1.

IMPROVEMENT OF THE SUSQUEHANNA RIVER, NEAR HAVRE DE GRACE, MARYLAND.

No appropriation was made for this work during the fiscal year ending June 30, 1876, and no work of any kind has been done. No examination of it could be made, and its condition is, therefore, not known.

F 2.

IMPROVEMENT OF NORTHEAST RIVER, MARYLAND.

No funds have been available for this locality during the fiscal year. No examination of it could be made, and its present condition is, therefore, not known.

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F 3.

IMPROVEMENT OF ELK RIVER, BELOW ELKTON, MARYLAND.

The original improvement proposed was to dredge a channel 75 feet wide and 6 feet deep at mean low-water, with proper side slopes, and also to construct over 4,000 linear feet of diking, from the confluence with Little Elk to the bridge at Elkton. A similar improvement was proposed for the Little Elk. Nothing has been done on the latter. A description of what was done on the former previous to June 30, 1875, may be found in the last annual report. At that date arrangements had not been made for the expenditure of the appropriation of March 3, 1875, $5,000.

After due advertisement for proposals, but one bid was received May 19, the day appointed for the opening. This was rejected, as being at a too high price. Efforts were continued to secure a proper person for the work at a suitable price until late in August, 1875, when Mr. A. A. Dodge, the bidder of May 19, offered to do what was required at about two-thirds of his first price. The reduction was from 34 to 25 cents per cubic yard for dredging, material measured in place. The material excavated was deposited in certain deep places in the river below, where the water was at least 24 feet deep at low-water, the arrangement being that no filling should be made to leave a depth of less than 18 feet at low-water.

The work proposed was to excavate a channel 40 feet wide at bottom, with proper slopes, with a depth of 6 feet at mean low-water, to extend from the iron bridge at Elkton to a point about a half mile below, and to make a basin near the wharves of the town for turning steamboats. The plan of dredging from one portion of the river and dumping the matter in another deeper portion was known to be a vicious one, but no other was practicable with the limited amount of money available, and the engineer was relieved of the responsibility, as it had been more than once officially reported that the improvement should not be undertaken with less than $20,000 available.

The work was begun September 30, 1875, and completed, as reported, February 12, 1876. The total number of cubic yards excavated in that interval was 15,565. A resurvey was made at once, and a map of the locality has since been prepared.

The immediate supervision of this improvement was committed to Mr. Henry Bacon, until he was transferred to the Cape Fear River, in North Carolina, in January, 1876, when Capt. C. B. Phillips, Corps of Engineers, relieved him at the Elk River and other works in Maryland.

The original estimate for this improvement, excluding Little Elk, was $30,000, and including it, $36,000. The appropriations have been: June 23, 1874, $5,000; March 3, 1875, $5,000; total, $10,000. If it be decided by Congress to complete the improvement as originally proposed, the remainder of the estimate should be appropriated in one sum, if true economy be followed, as the expense of any work is greatly increased by carrying it through several years, with intervals of suspension for want of funds.

Money statement.

Amount available July 1, 1875	$4,680 55
Amount expended during fiscal year ending June 30, 1876	4,680 55
Amount (estimated) required for completion of existing project	20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	20,000 00

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F 4.

IMPROVEMENT OF WORTON HARBOR, MARYLAND.

No funds have been available for this locality during the fiscal year. No examination of it could be made, and its present condition is, therefore, not known.

F 5.

IMPROVEMENT OF QUEENSTOWN HARBOR, MARYLAND.

No funds have been available for this locality during the fiscal year. No examination of it could be made, and its present condition is, therefore, not known.

F 6.

IMPROVEMENT OF CHESTER RIVER, AT KENT ISLAND NARROWS, MARYLAND.

The object of this improvement has been fully set forth in previous annual reports. Briefly, it consists in cutting a passage through the causeway across the Narrows, and dredging a channel 100 feet wide and 7 feet in depth at ordinary low-water, to the causeway, from Chester River on the one side and Easton Bay on the other. Although the first appropriation for this work ($15,000) was made in March, 1873, and a further appropriation ($5,000) was made in June, 1874, work was delayed until the spring of 1875, while waiting for certain legislative enactments on the part of the State of Maryland, without which it was deemed best (by the Secretary of War) for the General Government not to proceed with the work.

These obstacles having been finally removed, proposals for dredging were invited, and a contract was awarded to Mr. W. H. Beard, at 16⅞ cents per cubic yard. The contractor commenced work under his contract during the latter part of May, 1875, and at the beginning of the present fiscal year had removed only 10,000 yards of material.

Work was continued on the Easton Bay side of the causeway until September 2, when that portion of the work was completed; the channel having, however, been reduced to 80 feet in width, instead of giving it the full width of 100 feet as at first proposed.

From September until the following 17th of December, dredging was continued on the Chester River side.

On the latter date work was suspended on account of ice, and remained suspended until the 18th of February, 1876, when dredging was resumed, and has been continued through the balance of the fiscal year.

On the Chester River side the channel has been completed to 80 feet in width over the entire distance, and the dredges are engaged upon an additional cut which will give the full proposed width of 100 feet.

The counties of Queen Anne and Talbot, Maryland, having complied with the requirements of the legislature of Maryland in erecting a drawbridge at the causeway, the contractor, on the 15th of May, commenced cutting a passage through the causeway on the western side of the draw-pier. The passage was completed on the 24th of May, is 60 feet in width, and fully 7½ feet in depth at ordinary low-water.

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Amount of material removed by contractor during fiscal year about 88,000 yards. The water-way of the causeway is not sufficient and should be made wider.

The time for completion of contract was dated December 31, 1875. An extension of 6 months, or until June 30, 1876, was granted the contractor. A further extension of 60 days was afterward granted. It is not probable, however, that over 15 days will be required to exhaust the appropriation.

The original estimate for the improvement was $23,000, of which $20,000 were appropriated up to June 30, 1876. Three thousand dollars would complete the estimate; but owing to the long but unavoidable delay and protraction of the operations which have occurred, and the attending increase of expense, the sum of $5,000 will not more than complete the work estimated for. To keep this channel open when completed, occasional repairs will be required. Their cost will probably average $3,000 per annum.

Since January, 1876, the immediate supervision of this work has been committed to Capt. C. B. Phillips, Corps of Engineers, who then succeeded Mr. H. Bacon, assistant engineer.

Money statement.

Amount available July 1, 1875	$18,704 98
Amount expended during fiscal year ending June 30, 1876	13,330 83
Amount available July 1, 1876, including $1,282.73 due on contracts	5,374 15
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878, (see explanation above)	3,000 00

F 7.

IMPROVEMENT OF THE ENTRANCE TO THE HARBOR OF BALTIMORE, MARYLAND.

During the year operations in continuance of the improvement have been confined altogether to the Brewerton Channel. On the 30th of June, 1875, Morris & Cumings, as contractors, were engaged in adding about 40 feet to the width of that channel on the north side, making it about 300 feet wide. The work was continued until December 21, 1875, and then suspended on account of the severity of the weather. This opportunity was taken advantage of to make some small but needed repairs to the hull and machinery of the tug Leslie, belonging to the United States.

Work on the Brewerton Channel was resumed about the middle of March, 1876, and continued until the exhaustion of the appropriation early in June, 1876. Besides the widening of the channel, already mentioned, the turning-place was enlarged at the junction of the Brewerton and Fort McHenry Channels, near Fort Carroll. A cut was also made in the Brewerton Channel, at a distance of 45 feet from the north side, commencing at a point about 300 yards above its lower end, and was carried a distance of 2½ miles, or to a point nearly opposite the North Point buoy. This cut was made to a depth of 25 feet at ordinary low water. Not less than 23 feet depth of water, however, was found at any point over this distance. It is to be noted that more or less dredging may be expected to be annually required over this portion of the channel, which, from necessity, projects into and across the current of the Susquehanna River. The total amount of material dredged dur-

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ing the fiscal year has been 436,181 cubic yards. The contract-price, 12½ cents per cubic yard, including the expense also of re-deposit, is the lowest at which such work has been done on any improvement in my charge.

The object of this work has been to make such a channel as will enable vessels drawing 22½ or 23 feet to come to the city of Baltimore at any ordinary stage of the tide.

The object has been attained, but the width is the minimum. Any increase of width would be an improvement. As stated above, some shoaling may be always expected, but the small vertical movement of the tide, averaging only about 18 inches, the breadth of the expanse of the sheets of water through which the channel has been excavated, the great freedom from the influence of freshets, and the consequent feebleness of the currents, as well as the small amount of sedimentary matter, are circumstances favorable to the stability and permanence of the excavated channel. Its use by heavy ships will assist in keeping it open.

All routes of communication, such as railways, canals, ordinary roads, pavements, &c., require repairs. This channel is nothing but a canal in the bottom of a river, which will need annual repairs. The long steamers which use the channel, their length often greater than its width, sometimes slice off large masses from its sides with their sharp prows, and these are thrown down into the channel, diminishing its depth. It is estimated that a sum not less than $50,000 should be provided annually for dredging in this channel. It might be supposed by some that use should be made of dikes or jetties in connection with the dredging, but structures of this kind would be such a hinderance to the navigation of the lower Patapsco and Susquehanna by the numerous vessels of light draught as to be intolerable.

Since (in the last year or two) the channel has been better known at home and abroad, there has been a notable increase in the number of large vessels of heavy draught coming to this port, and to the same cause is due another remarkable feature of commercial development, the erection, by the great railroads terminating here, of vast wharves, store-houses, grain-elevators, &c.

An interesting statement is appended, prepared by Mr. George U. Porter, secretary board of trade, giving information regarding increase of tonnage, &c., since the opening of the new channel. This increase is the more remarkable in view of the great depression and stagnation which have prevailed in business generally.

The channel may be maintained in its present condition for the sum of $50,000 per annum, and that sum is the minimum deemed absolutely necessary, but, in view of the great importance of giving increased width to the channel, an appropriation of $210,000 is strongly recommended.

The work has been during almost the whole of the year, as for several previous years, under the immediate and efficient supervision of Mr. N. H. Hutton, who has lately been appointed engineer to the harbor commission of the city of Baltimore.

Money statement.

Amount available July 1, 1875	$69,485 87
Amount expended during fiscal year ending June 30, 1876	68,691 19
Amount available July 1, 1876	794 68
Amount appropriated by act approved August 14, 1876	75,000 00
Amount (estimated) required for completion of existing project. (see report of last year)	160,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	135,000 00

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COMMERCIAL STATISTICS.

The wisdom of improving the ship-channel of the Patapsco River and Chesapeake Bay is every day being demonstrated. Before this improvement was begun there was but a narrow zigzag channel leading to and from the port of Baltimore of 17 feet depth of water; now the channel is straight and wide, with but two bends where the Brewerton connects with the Craighill and McHenry Channels, and 24 feet of water. We have compiled, from the official reports of the Board of Pilots, the number of vessels piloted in and out of the port since the year 1872, showing the number drawing over 18 feet, and those less than 18 feet, by which it will be seen there is a very marked increase of heavy-draught vessels entering and leaving our port since the deepening of the channel. Another feature of this exhibit is, the lightness shown of vessels entering the harbor compared with those departing; this is occasioned by the larger class of vessels either coming in ballast or but partially loaded, whereas when they leave hence they are full to their capacity.

Vessels piloted to the port of Baltimore from January, 1872, to May, 1876, inclusive, showing the number for each month, with the draught of water of same.

Months.	Number of vessels.	18 feet and upwards draught.	Under 18 feet draught.
1872.			
January	55	3	52
February	48	3	45
March	60	3	57
April	96	8	88
May	88	1	87
June	102	6	96
July	55	1	54
August	52	2	50
September	67	2	65
October	61	5	56
November	62	4	58
December	57	1	56
Total	803	39	764
1873.			
January	51	3	48
February	48	2	46
March	90	5	85
April	98	7	91
May	104	1	103
June	86	4	82
July	76	2	74
August	82	2	80
September	78	3	75
October	86	3	83
November	62	3	59
December	63	4	59
Total	924	39	885
1874.			
January	68	3	65
February	78	3	75
March	128	3	125
April	107	5	102
May	86	3	83
June	104	2	102
July	74	5	69
August	82	.....	82
September	99	3	96
October	52	3	49
November	65	1	64
December	72	5	67
Total	1,015	36	979
1875.			
January	58	4	54
February	57	7	50
March	116	3	113
April	105	6	99
May	120	11	109
June	81	7	74
July	75	6	69
August	69	4	65
September	55	3	52
October	66	2	64
November	55	2	53
December	63	2	61
Total	920	57	863
1876.			
January	132	2	130
February	90	4	86
March	117	4	113
April	104	4	100
May	100	3	97
Total	543	17	526

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Vessels piloted from the port of Baltimore to sea from January, 1872, to May, 1876, inclusive.

Months,	Number of vessels departed.	18 feet and upwards draught.	Under 18 feet draught.
1872.			
January	75	13	62
February	68	15	53
March	54	12	42
April	78	10	68
May	101	13	88
June	87	9	78
July	81	16	65
August	56	6	50
September	53	7	46
October	52	12	40
November	69	8	61
December	56	11	45
Total	830	132	698
1873.			
January	74	16	58
February	68	11	57
March	76	12	64
April	106	12	94
May	105	17	88
June	91	14	77
July	73	11	62
August	76	9	67
September	81	8	73
October	72	11	61
November	81	13	68
December	71	8	63
Total	974	142	832
1874.			
January	90	19	71
February	61	12	49
March	86	10	76
April	118	18	100
May	110	31	79
June	89	13	76
July	78	22	56
August	71	12	59
September	76	8	68
October	71	15	56
November	65	9	56
December	60	14	46
Total	974	183	792
1875.			
January	76	15	61
February	48	10	38
March	95	20	75
April	108	28	80
May	94	22	72
June	81	27	54
July	81	20	61
August	71	17	54
September	55	18	37
October	58	9	49
November	51	10	41
December	58	11	47
Total	876	207	669
1876.			
January	108	29	79
February	108	24	84
March	115	31	84
April	97	32	65
May	115	33	82
Total, (five months)	543	149	394

RECAPITULATION.

PILOTED INWARD.				PILOTED OUTWARD.			
Years.	Whole number of vessels.	Total number of vessels over 18 feet draught.	Under 18 feet draught.	Years.	Whole number of vessels.	Total number of vessels over 18 feet draught.	Under 18 feet draught.
1872	803	39	764	1872	830	132	698
1873	924	39	885	1873	974	142	832
1874	1,015	36	979	1874	974	183	792
1875	920	57	863	1875	876	207	669
1876	543	17	526	1876, (five months)	543	149	394

In the foregoing figures we aim to show the increase of heavy-draught vessels entering our port since the depth of 24 feet has been attained in our river-channel. Annexed we give table showing the tonnage arrived since 1872, each succeeding year presenting an increase. Contrasting the first five months of 1876 with the same months of 1875, we find an increase in foreign tonnage of 116,006 tons, but in American a decrease of

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32,296; which latter represents the loss of sugar and molasses trade since the suspension of our refining interest. The aggregate of foreign and American tonnage, however, for the first few months of the present year, compared with the same period 1875, gives a total of increase amounting to 83,711 tons, and a much larger percentage than has characterized either of the preceding years.

TONNAGE AT THE PORT OF BALTIMORE.

The following shows the arrival of foreign and American tonnage from 1872 to May, 1876:

Year.	Foreign.	American.	Total.
	Tons.	*Tons.*	*Tons.*
1872	255, 251	99, 394	354, 645
1873	333, 652	118, 935	452, 587
1874	402, 811	135, 893	538, 704
1875	419, 741	129, 795	549, 536
1876, (five months)	312, 981	40, 637	353, 618

EXPORTS OF PETROLEUM.

The foreign exports of petroleum from the United States thus far for year 1876 present an aggregate of 90,385,299 gallons, against 86,846,697 gallons for same period 1875. New York shows a decrease this year of 12,411,617 gallons. Philadelphia, which lost heavily in 1875, has this year been recovering her exports, showing an increase of 9,302,210 gallons. Baltimore has been steadily gaining in this trade for past two years; her increase over 1875 amounts to 5,000,000 gallons, and compared with 1874 her increase shows, in round figures, over fourteen millions of gallons.

We give the figures from the respective ports, viz:

From—	1876.	1875.
	Gallons.	*Gallons.*
New York	45, 941, 340	57, 130, 399
Boston	1, 030, 525	1, 135, 386
Philadelphia	25, 619, 842	16, 317, 632
Baltimore	17, 231, 189	12, 263, 280
Richmond	562, 403	.....
Total	90, 385, 299	86, 846, 697

Shipments of petroleum from Baltimore prove to be still more active; 16 sailing-vessels are at present under engagement to load, their united capacity being 78,000 barrels.

F 8.

IMPROVEMENT OF CAMBRIDGE HARBOR, MARYLAND.

No funds have been available for this locality during the fiscal year. No examination of it could be made, and its present condition is, therefore, not known.

F 9.

IMPROVEMENT OF THE WICOMICO RIVER, NEAR SALISBURY, MARYLAND.

On the 30th of June, 1875, Mr. Parsons, the contractor, was engaged in dredging, his plan of procedure being to dump the material from the bucket of the dredge in the upper end of a long chute, floated on one or more scows, and to flood the material with water from a steam-pump, thus washing it through the chute over the dike, or on the flats below

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the dike. His chute was in longitudinal sections, in order that its length might be varied according to the distance of the dike from the dredge.

The original plan of improvement was to dredge a channel 75 feet wide and 7 feet deep at mean low water, and deposit the material behind longitudinal dikes. The work dragged through a portion of 1872, 1873, 1874, and a part of 1875, owing to insufficient means and other causes of delay. An interesting history of its progress, up to June 30, 1875, may be found in the last annual report.

The diking, which had also been in progress for more than a month before, was completed July 16, 1875, consisting of closing up the gap in the left dike from its upper end to the wharf, an extension of the lower end about 400 feet, and repairs of the dike already existing. The length of the new diking built was 1,636 feet, the adjacent land-owners furnishing the materials for about 900 feet of the distance, the United States doing all the work and furnishing the material for the remainder. The dredging and chuting were continued until the 7th of January, 1876, when the appropriation was exhausted.

It had been expected to use the available funds in making a channel 50 feet wide at bottom and 5 feet deep at mean low-water and preparing a basin near the wharves for steamboats to turn in. This channel, extending about 7,000 feet from the bridge at Salisbury to deep water below, would enable vessels drawing 7½ or 8 feet to reach the town at ordinary high-water; whereas, previously, all vessels drawing more than about 4 feet were obliged to receive and discharge their cargoes below, by the use of lighters, at a large expense, often amounting to a prohibition of water-carriage. The expense of lightering freight, then transported by the river, was estimated June 1, 1875, to be $7,000 per annum.

The channel was completed as stated, except for a short portion, which could be made only 38 feet in width, owing to the lack of funds. The total amount of material removed by Mr. Parsons was 44,487 cubic yards.

During the month of February, 1876, an examination of the channel was made, with a view to the preparation of a map exhibiting its condition at the close of operations. This map has been completed.

It was originally expected, as has been stated, to make a channel by dredging 75 feet wide and 7 feet deep at mean low-water, at a cost of $17,000, it being understood that the necessary dikes would be built by the citizens, at their own expense. The causes of the increased expense of the work were fully stated in the last annual report. It is believed that one of these, the inflow of sawdust from the mills, is now cut off almost entirely, unless in high freshets, when a portion may be still washed from the banks. The appropriations have been June 10, 1872, March 3, 1873, June 23, 1874, and March 3, 1875; total, $20,000. Should the original plan be carried out, an appropriation of $20,000 will still be required.

This work was supervised by Mr. Henry Bacon until the early part of January, 1876, and thereafter by Captain C. B. Phillips, Corps of Engineers.

Money statement.

Amount available July 1, 1875	$11,669 22
Amount expended during fiscal year ending June 30, 1876	11,598 18
Amount available July 1, 1876	71 04
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project, (see last annual report)	20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	15,000 00

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F 10.

IMPROVEMENT OF HARBOR OF CRISFIELD, MARYLAND.

The object of this improvement was to dredge a channel of 12 feet depth at mean low-water across the bar near Somers's Cove light to the railroad-wharf, and to make a basin for vessels at and near that wharf. The appropriation was $37,317.50. The work was awarded to Mr. G. H. Ferris, the lowest bidder. At the date of the last annual report he was engaged in the execution of his contract, which was carried steadily and faithfully on until the completion of the work at the close of May, 1876.

The contract-price being less than that of the estimate, and experience showing that unnecessary width had been originally assigned for the channel leading to the wharves, greater dimensions were given to the harbor or basin at the town.

This is a notable instance, so rare as to be worthy of special attention, in which Congress appropriated in one sum the whole amount of the estimate. The work has been successfully accomplished within a reasonable time, and is satisfactory to all concerned. It is to be regretted, in the interest of true economy, that the same procedure could not be followed in many other similar cases.

The result of the work at this place has been the excavation of a channel, 266 feet in width and 12 feet in depth at ordinary low-water, from above the railroad-wharf to a point known as the second angle, (opposite Somers's Cove light,) and from this point to the deep water below a channel of the same depth 425 feet in width.

In addition to this, a basin has been excavated on both the north and south sides of the railroad-wharf, 12 feet in depth at low-water. On the south side this basin has been excavated to within 8 feet of the oyster-houses to the south and east, or over all the area available. On the north side the basin has been excavated to a width of 100 feet from the railroad-wharf, and, in addition, two cuts, aggregating 56 feet in width, have been made in front of the oyster-houses, on this side of the basin. The latter two cuts, however, were excavated only to a depth of 9 feet at low-water. Proper approaches have been excavated from each portion of the basin to the main channel. The total amount of material removed during the entire operations has been 238,389 cubic yards.

Mr. Henry Bacon was the immediate supervisor of this work until his relief in January, 1876, by Capt. C. B. Phillips, Corps of Engineers. A resurvey was made immediately upon the completion of the work, and a map prepared showing its condition at the close of operations. It is to be remembered, however, that reparations will in time be necessary for this dredged channel and harbor, just as they are occasionally to all highways, canals, ordinary roads, &c.

Money statement.

Amount available July 1, 1875	$35,575 62
Amount expended during fiscal year ending June 30, 1876	35,555 84
Amount available July 1, 1876	19 78

F 11.

IMPROVEMENT OF THE JAMES RIVER, VIRGINIA.

Mr. H. D. Whitcomb has continued the resident assistant engineer for the United States at Richmond, while at the same time engineer for

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the city in the joint operations for this improvement. He has given much study to the regimen of the river, the results of which appear in the interesting and instructive report submitted by him and appended hereto. Reference to it is requested for information as to details of work done and still required.

On the James River, as in many other instances, the appropriations have been generally inadequate to the execution in proper order of the several parts of a well-considered project of improvement. The successive operations have been necessarily to a great extent intermittent and incomplete, and therefore unsatisfactory and expensive. Sometimes, under the pressure for immediate relief to commerce, a quick method has been resorted to, like dredging, when a slower process would have produced more lasting effects. Notwithstanding such difficulties, there has been in the past few years a marked improvement in the condition of the James River, and a point is now reached when the outlook is very favorable for the attainment of a still more important and permanent gain in width and depth of navigable channel at a moderate expense. It may be fairly said that the worst obstacles existing to the navigation 5 years ago have been either entirely removed, or are in a fair way to be at no distant day, if funds are provided, as asked for.

With the additional information gained as to the condition of the river by further surveys, a better knowledge of the wants of the commerce now on it, or to be reasonably expected, as well as of the prices at which work of various kinds may be done, the estimate submitted with the annual report of 1874 has been revised by Mr. Whitcomb at my request. It is for a channel 15 feet deep at mean low-water and 180 feet wide as far down as Harrison's Bar, and for a partial improvement there. Additional surveys are required at that point and at others.

The estimate of 1874 was	$408,925 00
The appropriations since have been: June 23, 1874, $50,000; March 3, 1875, $50,000; total	100,000 00
Leaving balance to be provided	308,925 00
The present estimate of Mr. Whitcomb is	293,808 00

Money statement.

Amount available July 1, 1875	$47,555 09
Amount expended during fiscal year ending June 30, 1876	47,450 50
Amount available July 1, 1876	104 59
Amount appropriated by act approved August 14, 1876	60,000 00
Amount (estimated) required for completion of existing project	293,808 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	140,000 00

REPORT OF MR. H. D. WHITCOMB, ASSISTANT ENGINEER.

RICHMOND, *July* 1, 1876.

COLONEL: I have the honor to submit the following report on the improvement of James River for the year ending June 30, 1876.

The work was confined to the schedule mentioned in the last report, with one exception, and was executed as follows:

At the letting, June 4, 1875, bids were received for excavating a channel through Gillie's Creek Shoal, for completing the dike at the head of Drury's Island, and for widening the Dutch Gap Canal. Only 1 bid was received for the work at Gillie's Creek Shoal, and that not satisfactory. The contracts for the dike, and the excavation at the canal above water, were let to R. T. Hieston; and for canal excavation below water, to Mr. M. Meehan. The remainder of the work was done by a Government force, using the rock-drilling machinery belonging to the United States, and the dredges, tugs, barges, dumping-machines, and pile-driver belonging to the city of Richmond, which were furnished to the United States at a rental not exceeding the cost of repairs.

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CHANNEL THROUGH GILLIE'S CREEK SHOAL.

The only bid received for this work was at the rate of 50 cents per cubic yard for ordinary excavation, $1.50 per cubic yard for loose and soft rock, and $2.50 per cubic yard for solid rock, the latter to be loosened by the United States; the material, after removal, to be measured in buckets as called for in the specifications. This was considered unsatisfactory. A channel, 90 feet wide, has been excavated to the depth of 15 feet at low-tide, (with the exception of small areas of rock near the sides, where there are 14 feet,) including the removal of 196 cubic yards of solid rock; and cost the United States about 35 cents measured as above, or say 50 cents measured in place. The material was "decomposed-rock" bowlders, and some solid rock. The channel is but one-half the full width, but is used by the larger class of vessels, and permits any which can cross the miter-sill of the Richmond dock to proceed to sea.

COMPLETION OF THE DIKE AT THE HEAD OF DRURY'S ISLAND.

This work, 1,326½ feet long, was completed by Mr. R. T. Hieston, contractor, in September, 1875, and answers the purposes intended.

CHANNEL AT GOODE'S ROCKS.

This work was of a character so uncertain that it could not be let to contract without risk to both parties. The United States had the proper machinery for the work on the spot, and it was carried on by a Government force. It proved to be a more formidable obstacle than was supposed. The few rocks which obstructed our otherwise fair channel of moderate depth were supposed to rest on a spur from the adjoining quarry. The remainder of the shoal appeared to be sand. The removal of these rocks, which proved to be bowlders, as was supposed, and the subsequent scour of the sand in which they were imbedded, disclosed the fact that the bed of the river for a considerable area was composed of bowlders, often of great size. We failed to remove all of these, even to a depth of 10½ feet at low-tide, for want of means, and this channel has not been opened for navigation, although used occasionally by vessels of light draught. By a recent survey, there is an area of 106,000 square feet, on which an average depth of 1.9 feet must be excavated to give 15 feet at low-tide. The sounding-rod struck rock 38 times in every 100. The greater part of the channel, for a width of 80 feet, was cleared of rock and sand to a depth of from 13 to 13½ feet, and a comparatively small sum will open this width to that depth at low-water. The rock excavated was used in making dikes and wing-dams in the vicinity. The circuitous channel which avoids these rocks continues to be used by vessels, and has a depth of 10½ feet at low-tide. The completion of even the narrow channel mentioned will be a great improvement.

DIKES AND WING-DAMS AT RICHMOND BAR.

The dike on the left bank of the river was completed, and certain wing-dams on the right bank constructed, mostly out of materials on hand, by a Government force, and have assisted in the reduction of this bar, as will be shown further on in this report.

DUTCH GAP CUT-OFF.

Mr. Hieston excavated 18,674 cubic yards above water, and Mr. Meehan 17,212 cubic yards below water, the total cost to the United States being $11,870.25. The contracts were closed in February, 1876. The canal is now 180 feet wide at surface, and has a depth of about 15 feet at low-tide. It can be used by all classes of vessels coming to Richmond, but would be greatly improved by a further enlargement. Further reference to this work will be found elsewhere in this report.

AMOUNT OF WORK DONE.

The following statement gives the cubic yards removed both by the United States and by the city of Richmond for the year ending June 30, 1876:

	By the United States.		By the city.	
	Earth.	Rock.	Earth.	Rock.
New channel, Gillie's Creek Shoal	18,794	196	16,986	138
Deposit from freshet 1876 (March) near ship-lock	.....	.....	3,168	.....
Richmond and Danville Railroad wharf	.....	.....	212	.....
Firebrick-yard cut, enlargement of channel	.....	.....	17,736	66
Side-channels to Drury's Island dike	4,148	.....	.....	.....
Chesapeake and Ohio Railroad wharves	.....	.....	8,616	.....
Deposit from freshet March, 1875, (July, 1875)	.....	.....	4,692	.....
New channel at Goode's Rocks	1,600	949	520	200
Dutch Gap Canal enlargement	31,016	.....	.....	.....
Total	55,558	1,145	51,930	398

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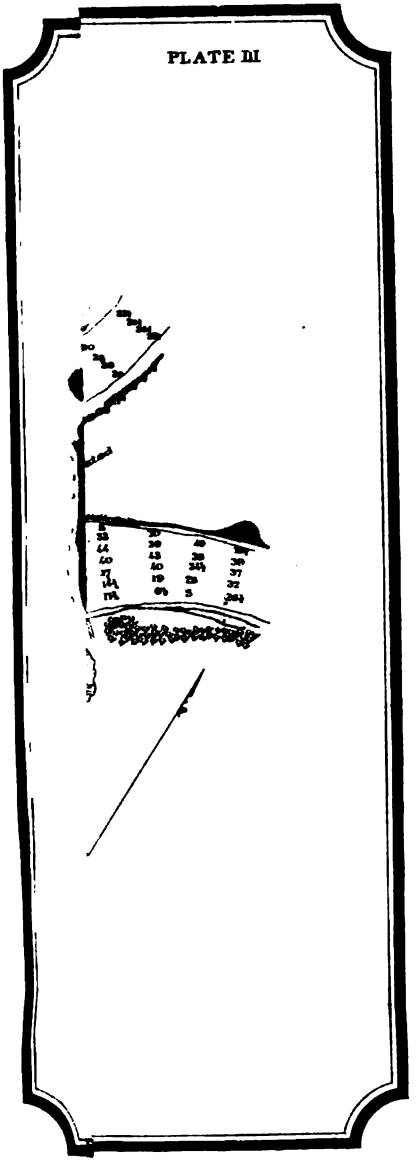
PLATE III



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he United States have built dikes and wing-dams as follows:

	Feet.
pper end of Drury's Island, by contract	1,326½
Richmond Bar, by Government force	683
Randolph's Flats, by Government force	788
Total	2,797½

or want of funds, no effort was made, as had been contemplated, to close the station-dikes bordering certain parts of the river, broken during the civil war.

he condition of the river is better than it was a year since.

he new channel through Gillie's Creek Shoal permits vessels of 14 feet draught to re the dock and proceed to sea. The shallow reach below Rockett's Reef has been deepd to some extent by dredging and widened by scour. The channel over Richmond has been increased 100 feet in width by scour alone, and Dutch Gap Cut-off is imved so that, except under certain combinations of wind and tide, it can be used safety by the largest class of steamers coming to this port.

or the first time, so far as I can learn, a freshet has produced an improvement on hmond Bar, due, it is clear, to the contraction of its width, as will be shown presly. The freshet of this spring left no observed injurious deposit in the channel, ept at the entrance to the ship-lock, due probably to the pier on the south side of entrance, which causes no eddy.

he improvement has reached a point where the future seems clearer, and means for ther improvement can be applied with more decision, and temporary measures for ping the channel open will, I think, be more rarely required.

A review of the condition of the river in 1869 and after the great flood of 1870, when work of improvement was begun in earnest, may be interesting.

I will quote from a letter on this subject from Capt. Thomas Cunningham, sr., who been connected with the improvement for many years, and whose thorough knowlge of the river will not be questioned. He says:

"The river was at that time (April, 1869) pretty full of obstructions from the shipk down the river below the Dutch Gap. There was the wreck of the West Point, ng bottom up; there was a lighter sunk in the channel just below the brewery-harf. Richmond Bar had filled up to about 11½ feet at high-tide; there were obstrucns at Warwick Bar, Drury's Bluff, Graveyard Reach, Trent's Reach, and at the lower d of Varina Reach; also, several old wrecks on the side of the channel. In a word, expressed by some captains of steamers trading to the city, 'was full of obstructions d rocks.' On the 30th September and 1st October, 1870, we had a great flood, which ed up the river to an alarming extent. Trent's Reach, 20 miles down the river, was ed up to about 10½ feet at high tide; Richmond Bar to nearly the same; Randolph's ats very little better. Near the ship-lock and some distance below filled up likewise; a word, the river had filled up so much that the larger New York steamships ceased run to the city for several months."

At this time the Dutch Gap Canal was not open to any kind of navigation. A road d been made across its upper end. This work was proposed, I believe, by Captain anabury, of the Engineer Corps, as early as 1852, but nothing was done toward its ecomplishment until during the civil war, when it was partially opened by the United tates to aid in military operations. Before it was completed, however, the close of he war removed the necessity for it, and the proprietor of the land through which it s made closed it, as before stated. It remained in this condition until the extraordiary flood of 1870, which washed out the road, and left the work as represented in Plate I, which is copied from a map made from a survey under your direction. The United States then undertook to open the canal for navigation. It was first enlarged o 120 feet width and about 14 feet depth at low-tide, and was opened to navigation in 1872, and for a time was used by all classes of vessels trading to Richmond.

Subsequently a slide on the right bank diminished the water-way very seriously, and the larger side-wheel steamers abandoned its use. During the past year the canal has been further enlarged, and is now about 180 feet in width by 15 feet in depth at low-tide. Its present condition is shown on Plate II, and the bend cut-off on Plate III. A further enlargement, both in width and depth, is desirable. Whenever the improvement is so advanced as to allow vessels of 18 feet draught to go to Richmond at *high-tide*, as is contemplated, it would be desirable to have at least that depth at *low-tide* at this point, as well as on all the shoals below Warwick Bar, so that vessels drawing 18 feet would not be compelled to stop at low-tide while on the way. The current through the canal due to tides has been reduced by the enlargement, (*i. e.*, it appears so, but no measurement has been made of the current since the enlargement,) but it is still stronger than it should be, either for the regimen of the river above and below, or as affecting navigation. Any further enlargement would tend to correct this.

The obstructions mentioned in the letter of Captain Cunningham (quoted above) were placed in the river during the civil war, and mainly by the confederate author-

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ities. They were generally made with sunken vessels and cribs, filled with stone. These have been removed at the expense of the United States. Some of the cribs near the left bank at Warwick Bar have been left in place, and have, probably, by contraction caused the present increased depth on that bar, or rather on its crest. There are now 13 feet at low-tide, and the river has this depth for some distance above. Portions of the cribs which were sunk near the channel also remain, and, although not in the way of vessels of the usual draught, are probably dividing the current, and should be removed, or their injurious effect counteracted when the improvement of that part of the river is in hand.

One of the most serious obstacles to navigation on this river was the granite reef at Rockett's. There were less than 12 feet on this reef at high-tide in 1871, and this by a narrow, crooked channel. It occupied the bed of the stream for about 500 feet. The channel has been much improved; its width, at 14 feet depth at high-tide, is not less than 100 feet, and, by a narrow channel, 15 feet may be carried. I advise that a part of the appropriation for the current year be used in giving 30 feet more width, and in deepening a portion of the channel to 15 feet at *low-tide*. Plate IV shows cross-sections of this reef at the upper and lower ends, and at a point near the middle, where it is, perhaps, more obstructed than at any other point. Plates V and VI give plans of the reef in 1871 and 1876, showing contour-lines for every foot in depth. I have been informed by Mr. C. L. Kalmbach, who superintended the work of enlargement, that the ledge in the channel was broken up to a depth of 20 feet, but that portions of it under the 15-feet-high-tide depth were not removed on account of the limited appropriations. No work has been done here since July, 1874.

Two registering tide-gauges were put in operation in September, 1875—one at the Chesapeake and Ohio Railroad wharf, and the other at Dutch Gap, near the lower end of the canal, on the left bank of the river, to the right of the canal. An abstract of the observations for 9 months, ending May 31, is given below. The tides affected by freshets are excluded in getting the *average* rise and fall, but all others are retained, including those affected by high winds.

At Chesapeake and Ohio Railroad wharves, 1¼ miles below the dock.

Months of 1875 and 1876.	Lunitidal interval.		Duration.		Mean height above zero.		Rise and fall.		High-water above zero.		Low-water above zero.		Mean rise and fall.	
	High-water.	Low-water.	Flood.	Ebb.	High-water.	Low-water.	Least.	Greatest.	Highest.	Lowest.	Highest.	Lowest.	Scale.	Staff.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
September..	16 57	23 57	5 20	7 05	3.63	—0.17	2.02	4.75	4.50	1.86	1.05	—1.55	3.62	3.80
October.....	17 16	24 17	5 25	6 58	3.36	—0.45	2.50	4.65	4.40	2.30	0.60	—1.87	3.81	3.61
November..	17 20	24 25	5 21	7 05	3.38	—0.24	2.46	4.56	4.32	1.90	1.05	—1.80	3.61	3.62
December..	17 09	24 30	5 05	7 20	3.20	—0.20	2.05	4.50	*5.60	1.65	1.95	—1.55	3.39	3.39
January....	17 03	24 29	4 59	7 25	2.90	—0.61	2.10	4.35	3.82	1.40	1.30	—1.95	3.52	3.51
February...	17 07	24 40	4 48	7 38	3.06	—0.23	1.65	4.25	3.95	1.40	1.25	—2.40	3.29	3.29
March.....	17 20	24 44	5 03	7 26	3.39	+0.21	1.54	4.00	*12.10	1.56	1.67	—1.22	3.13	3.17
April.....	17 30	24 41	4 58	7 27	3.69	+0.55	1.60	4.41	4.79	2.14	2.82	—0.90	3.14	3.13
May.....	17 10	24 40	4 55	7 32	3.72	+0.25	2.05	4.35	4.77	2.70	1.75	—0.80	3.48	3.47
Mean.....	17 09.7	24 27.9	5 07	7 18.4	3.350	—0.137	....	....	.....	.....	.....	.....	....	3.487

* Freshets.

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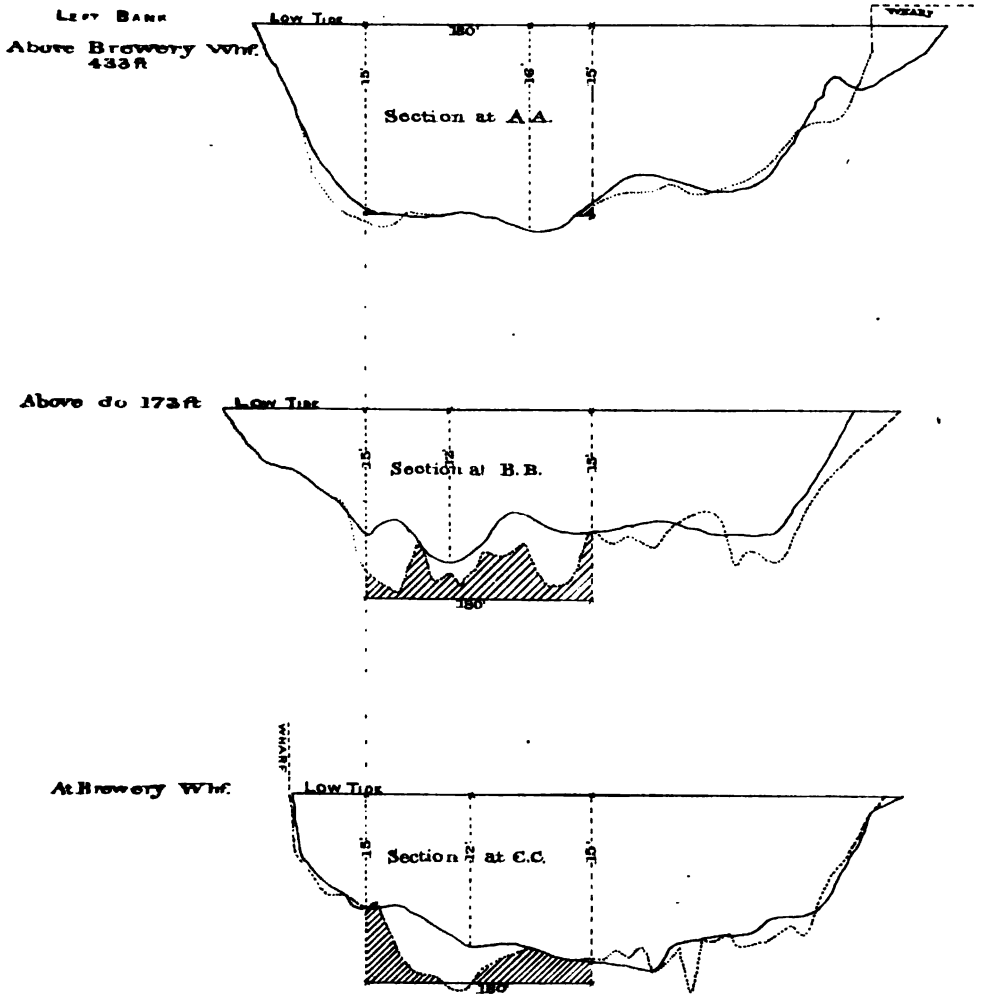
PLATE IV

Sections at Rocketts Reef 1871 and 1876



Channel to be 180ft x 15ft at L.W.

Continuos line bottom of 1871

Broken do do 1876

Shaded part to be excavated

Horizontal scale 150ft. Vertical 15ft. to 1in.

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PLATE V

ROCKETTS REEF,

1871.

Scale

NOTES

Depths from Mean L.W.

0 to 9ft.

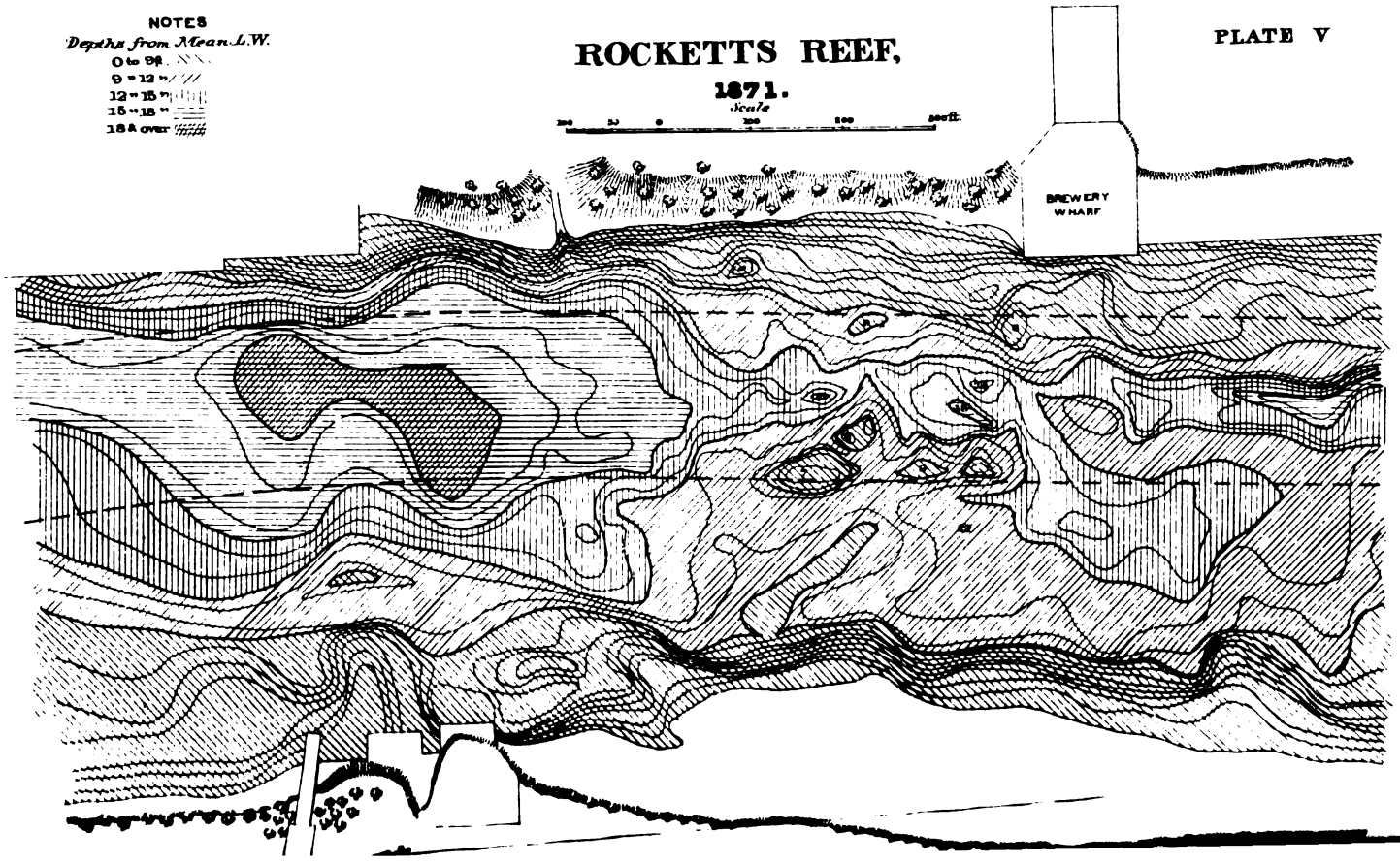
9 " 12 "

12 " 15 "

15 " 18 "

18 & over

BREWERY WHARF



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NOTES

Depths from Mean L.W.

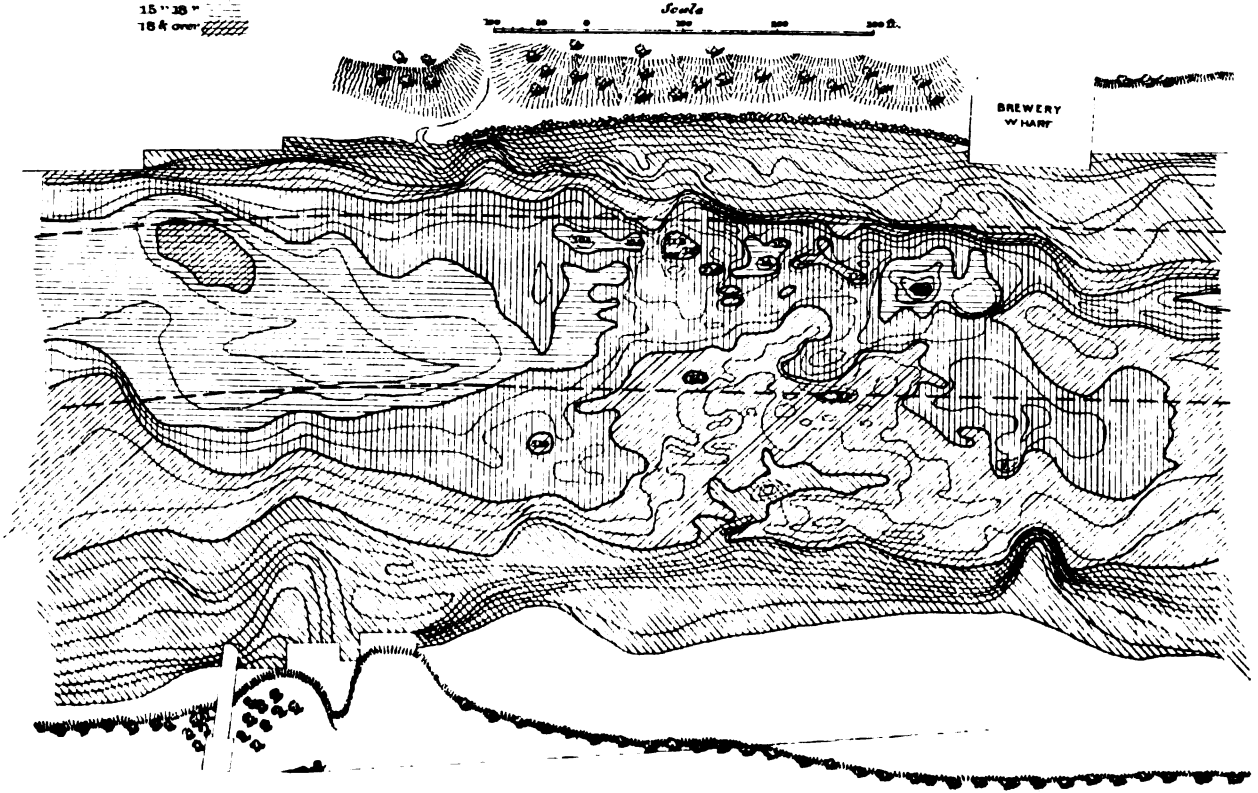
0 to 9 ft.
9 " 12 "
12 " 15 "
15 " 18 "
18 ft over

ROCKETTS REEF,

1876.

Scale

PLATE VI



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At Dutch Gap Cut-off, lower end, 19 miles below Richmond.

Months of 1873 and 1874.	Lunitidal interval.		Duration.		Mean height above zero.		Rise and fall.		High-water above zero.		Low-water above zero.		Mean rise and fall.	
	High-water.	Low-water.	Flood.	Ebb.	High-water.	Low-water.	Least.	Greatest.	Highest.	Lowest.	Highest.	Lowest.	Scale.	Staff.
	h. m.	h. m.	h. m.	h. m.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
September..	16 23	23 11	5 40	6 45	3.39	0.74	1.03	3.23	4.34	1.75	2.34	—0.36	2.66	2.65
October.....	16 26	23 08	5 42	6 42	3.16	0.50	1.86	3.43	4.20	2.22	1.37	—0.62	2.66	2.67
November..	16 28	23 16	5 37	6 50	3.24	0.68	1.65	3.31	4.30	2.05	1.95	—0.60	2.57	2.56
December ..	16 34	23 36	5 24	7 00	2.91	0.26	1.92	3.69	*5.22	1.81	1.52	—0.69	2.65	2.65
January	16 26	23 20	5 30	6 55	2.76	0.13	1.51	3.18	3.74	1.27	1.05	—0.96	2.64	2.64
February ...	16 18	23 19	5 24	6 59	2.90	0.34	1.47	3.35	3.68	1.73	1.05	—1.20	2.56	2.56
March	16 29	23 26	5 30	6 56	3.06	0.64	0.31	2.89	*5.81	1.42	1.72	—0.33	2.43	2.42
April	16 07	23 08	5 13	7 12	3.34	0.77	1.57	3.37	4.41	1.84	1.84	—0.41	2.60	2.58
May	16 07	23 12	5 21	7 10	3.30	0.57	2.12	3.63	4.20	2.04	1.90	—0.27	2.73	2.73
Mean.....	16 24.7	23 16.6	5 29	6 56	3.134	0.525	....	....	.....	.....	.....	.....	....	2.609

* Freshets.

NOTE.—The means, given at the bottom of the tables, are from the sums of all the *observations* in the months, and not from the sums of the *means* of the several months given in the tables.

It will be seen from the above, which I regret are not complete for 12 months, that the average rise and fall, as well as zero, vary considerably in different months. This is due mainly to prevailing winds. Thus far it seems that at Dutch Gap zero, according to the levels of 1852, is more nearly true than that found by Mr. Popp in the survey of 1874. He reports "that low-water is now (1874) apparently 0.63 foot lower than it was in 1872."

ANALYSIS OF THE SURVEY OF 1874.

Some of the characteristics of James River were given in the last annual report, and during the winter I have made an analysis of the survey of 1874, made by Mr. William Popp, under your direction, which is submitted. This survey gave the widths and depths at mean low-tide from the ship-lock in Richmond to the lower end of Dutch Gap Canal by way of the bend at Osborne's, a distance of 19.3 miles, the canal saving 5 miles of navigation. The lines of soundings were generally at right angles with the direction of the current, and were taken at intervals of 20, 50, 100, and 200 feet in the length of the river, as the condition of its bed required. The soundings across the river were from 10 to 15 feet apart. The survey included the leveling to ascertain the low-water slope and observations on the tides.

In making the analysis, I have taken from the map the cross-section at average distances of 500 feet, and ascertained the width, channel, and mean depth, and sectional area at each point. From the areas was ascertained the position of a vertical line dividing the mass in 2 equal parts on each line; the points marking the position of these lines were located on the maps, and curves made to pass through them. Tables 1, 2, 3, 4, and 5 give the widths, depths, and areas, and the radii and direction of curves, and the number of degrees in each. I have divided the river within the limits of this survey into 5 sections, 4 of these reaching in the aggregate to the entrance of Dutch Gap Canal, and the fifth covering the bend cut-off. The curvature in the fifth section is not given. Table No. 6 gives the mean, and the greatest and least widths, depths, and areas on each of the 5 sections, and table No. 7 the mean depths and areas corresponding to various surface-widths.

	Feet.
The first section is from Richmond to Randolph Flats	19,500
The second section ends at Drury's Bluff	18,500
The third section ends at end of Kingsland's Reach	18,500
The fourth section ends at entrance to Dutch Gap Canal	18,500
The fifth section includes the bend cut-off	26,500

With the exception of Kingsland, sometimes called Grave-yard Reach, which is at the end of third section, all the difficulties to navigation at high-tide between Richmond and Dutch Gap, for vessels drawing 18 feet and under, are confined to the first 2 sections, and end with Warwick Bar, 5¼ miles below the city. The least mid-channel depth in Kingsland's Reach is 13½ feet at low-tide, and there are 1,100 feet with less than 15 feet; elsewhere below Warwick Bar there are 15 feet and over; the mean rise and fall of tides being about 3½ feet.

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The river varies considerably in width above Warwick Bar, and is more uniform below, (excepting Kingsland's Reach,) at least to the entrance of the Dutch Gap Canal. Table No. 6 shows that the widths *diminish* and the depths and areas *increase* from Richmond down, the only exception being the width of section 5, on which the shoal in Trent's Reach is a leading feature.

As the river has few and inconsiderable affluents in the distance covered by this survey, and these could not account for the increased sections, I was interested to know whether the lower sections, *i. e.*, those below Richmond Bar, were to be considered an estuary, as was assumed by me in the last annual report, and by Mr. Popp, in his report on the survey; or if the decrease in the *slope* of the river at low-tide on the lower sections required the larger area observed, Mr. Popp ascertained the slope by leveling at extreme low-tide, on a favorable day, at 4 points, and made the fall as follows:

	Feet.	Feet.
From Rockett's Reef (¼ mile below dock) to Richmond Bar	12,320	0.58
From Richmond Bar to Drury's Bluff	22,180	0.14
From Drury's Bluff to entrance of Dutch Gap Canal	37,500	0.10
Totals	72,000	0.82

These points do not correspond with the divisions I have mentioned, and in order to discuss the effects of the slopes, corresponding to these levels, another division into 3 sections has been made. On these 3 sections the mean widths, depths, and areas were ascertained, as well as the aggregate curvature, and are given below:

	No. 1. Rockett's Reef to Richmond Bar.	No. 2. Richmond Bar to Drury's Bluff.	No. 3. Drury's Bluff to Dutch Gap Canal.
Mean of surface width.....(W)..	906 ft.	802.5 ft.	613.4 ft.
Mean area.....(*a*)..	5,856.6 sq. ft.	8,319 sq. ft.	1,011 ft.
Mean wetted perimeter, (W × 1.015).....(*p*)..	818.09 ft.	814.54 ft.	6,296 ft.
Mean radius, prime, $\frac{a}{W \times p}$.....(r_1)..	606	5.1446	8.9086
Slope per foot.....(S)..	000047	0.0000063	0.000002867
Degrees of curvature.....	125° 30′	127° 42′	757° 49′

The mean velocity corresponding to these elements was then ascertained by the Humphreys and Abbot formulæ as given in their work on the Physics and Hydraulics of the Mississippi, viz: $v = \sqrt{0.0081\, b + (225\, r_1\, S^{\frac{1}{2}})^{\frac{1}{2}} - 0.09\,(b^{\frac{1}{2}})^2} - \frac{2.4\,(r')^{\frac{1}{2}}}{1 \times p}$ for sections 1 and 2, where the mean radius is less than 12, and $v = ([225\, r_1\, S^{\frac{1}{2}}]^{\frac{1}{2}} - 0.0388)^2$ for section 3. The correction for curvature was made from their formula $p = \frac{v^2\, N.\, \mathrm{Sin}^2 30^\circ}{134}$, where N represents $\frac{\text{curvature}}{30}$ and p the fall equivalent to the resistance. The calculation for velocity and discharge, neglecting the influence of bends, resulted as follows:

	Section No. 1.	Section No. 2.	Section No. 3.
Velocity in feet per second	2.1591	1.5480	1.7064
Discharge in cubic feet per second	12,645.	12,877.	18,788.

The correction for curvature gave the following result:

	Section No. 1.	Section No. 2.	Section No. 3.
Equivalent slope per foot	0.00004412	0.000005454	The correction gives a negative fall of −.03 in this 7 miles.
Corrected velocity in feet per second	2.1227	1.4898	
Corrected discharge in cubic feet per second	12432.	12393.	

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The negative result on section No. 3 may result in part from an error in the level of low tide at the entrance to Dutch Gap Canal, which is the end of this section. Owing to the canal which cuts off 5 miles of the river, there is a great disturbance in the tides at that point, and is well described in the report of Mr. W. Popp, as follows: "When the flood-wave reaches the lower end of the canal, the main wave travels past it and around Farrae's Island, a distance of 5 statute miles, to the upper end of the canal. In a few minutes the level at the lower end has risen sufficiently to create a current up-stream, which rapidly increases in velocity. When reaching the upper end of the canal the water carried up by this current reaches the ebb slope and passes down-stream until the main wave reaches the place. The same thing occurs in a reversed order at the beginning of ebb. The duration at this interesting phenomenon lasts sometimes for 15 to 20 minutes. The tides observed at Dutch Gap were much more irregular than those at other places. The mean fall between the two gauges* during flood was about ¼ inch, during ebb about 1¼ inches."

It seems probable that the tide does not fall so low at this point as it did before the canal was opened, which may have been 2 years previous to the survey. A fall of 0.23 foot instead of 0.10 foot in this 7 miles would give the same discharge by formula as was found on the other sections, but the disturbance would scarcely account for all the difference, since in the 20 minutes preceding low tide the fall is only about 0.05 foot. The greatest care is necessary in making these observations to insure accuracy; and the difficulty in leveling for so long a distance with such accuracy as these small differences require, unless by repeated corrections, is well known. Du Buat's formula for the retarding influence of bends, $h_{11}=\frac{v^2\,N-\sin 30^\circ}{266.3}$, applied to the James, gives the discharge on No. 1 at 12,539 cubic feet, on No. 2 at 12,640 cubic feet, and on No. 3 at 13,833 cubic feet. Assuming that the *observed* slope on No. 3 was correctly taken, it is evident that the correction by this formula is too small on the James, as it had been found to be on the Mississippi. My impression is that further observations will show that the Humphreys-Abbot formula is more nearly correct. However this may be, the close results obtained on sections of the river varying so widely in slopes, widths, areas, curvatures, and lengths, can scarcely be considered a fortunate balancing of errors, and is to me a proof of the great accuracy of the Humphreys-Abbot formula, and their applicability to the part of the river under consideration, and I am forced to the conclusion that these 3 sections at least do not constitute an estuary proper, but that the areas are regulated by the discharge, and are not a matter of chance. With this view, any attempt to maintain a greater area without repeated dredging will result in failure. On the other hand, it is plain that any reasonable depth may be maintained by so contracting the width as to preserve the proper area at that depth. There may be points where, owing to the presence of rock or other resisting material, the river has not yet attained to its proper section, as, perhaps, at Rockett's Reef. In such places the area can be permanently increased. Experience leads me to expect that with a mimimum surface-width of 500 feet, a depth of at least 15 feet at low tide can be maintained to the gates of the Richmond dock.

Partly with a view to further test the accuracy of the result given above, but chiefly to gain information as to the slopes, and particularly those above Warwick Bar, the 3 sections were divided into 15, the points selected being those where a change in slopes would be likely to be found. The discharge found in the previous investigation was assumed to be correct. The mean areas, &c., for those subdivisions were ascertained from the tables 1 to 4, inclusive, the slopes on each calculated by—

$$S=\left(\frac{(v^{\frac{1}{2}}+0.0388)^4}{225v}\right)^2$$

(H. & A.,) and then corrected for curvature as before. The result is stated in the following table and shown in the accompanying diagram. The observed point on Richmond Bar did not coincide with the subdivision, and on the two sub-sections, reaching from the lower end of Drury's Island to the lower end of Randolph's Flats, I further subdivided the distance into lengths of 1,000 feet, and applied the same formulæ to them. The full lines represent the observed slope, the broken lines the slopes of the subdivisions from calculations, and the *dotted* line the lesser divisions over Richmond Bar, also from calculation. At the first observed point the calculated slope passes very near; at Drury's Bluff it is 0.02 foot below, and at Dutch Gap 0.007 foot below. These tests seem to me very severe, and I may not be presuming too far in saying that in the regulation of the river the proper width may be found at every point by a general conformity to the formulæ. In giving the table and diagram it is proper to say that the slope above Rockett's Reef is from calculation alone; the low-tide elevation, as compared with that at Rockett's, has not been ascertained by leveling.

* One at upper and one at lower end of canal.—H. D. W.

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Section.	Number areas averaged.	Length of section in feet.	Average area, a.	Average width.	Velocity, $\frac{Q}{a}$	Radius prime.	Slope.	Fall.	Degrees curvature.	Correction due to curvature.	Corrected fall.	Total fall from Rockett's Reef.
									° ′			
1	7	3,500	6,193	613	1.9801	5.0138	0.0000186	0.09307	00 00	.....	0.0615	
2	11	5,500	5,284	736	2.3208	3.5629	0.0000552	0.30358	37 20	.01185	0.315430	0.315
3	10	5,000	6,359½	760·	1.929	4.153	0.0000198	0.09894	78 10	.01805	0.116990	0.432
4	11	5,500	6,399	1,059	1.917	2.999	0.0000370	0.20373	19 50	.01810	0.221830	0.654
5	8	4,000	7,863	919	1.568	4.246	0.0000084	0.03380	12 37	.00193	0.035726	0.690
6	9	4,500	8,712	844	1.414	5.126	0.0000039	0.01748	14 00	.00193	0.019222	0.709
7	11	5,500	8,826	668	1.430	6.557	0.0000025	0.01364	31 15	.00397	0.017688	0.727
8	9	4,500	9,580	722	1.317	6.585	0.0000018	0.00805	60 20	.00603	0.014553	0.741
9	10	5,000	10,632	555½	1.187	9.488	0.0000006	0.00288	70 15	.00758	0.010447	0.752
10	10	5,000	10,848	608	1.164	8.855	0.0000006	0.00306	74 00	.00624	0.009305	0.761
11	10	5,000	10,312	680	1.225	7.526	0.0000010	0.00516	35 55	.00362	0.008771	0.770
12	8	4,000	10,471	836	1.206	6.216	0.000014	0.00570	69 50	.00632	0.012019	0.782
13	9	4,500	11,575	667	1.091	8.612	0.0000005	0.00268	103 45	.00768	0.010363	0.792
14	9	4,500	11,602	507	1.089	11.356	0.0000003	0.00129	147 21	.01086	0.012156	0.805
15	19	9,500	11,511	547½	1.097	10.434	0.0000004	0.00335	256 43	.01922	0.022564	0.827

The second section on the table is a reach where there were formerly two channels, divided by Drury's Island. One of these is shut off by dikes, and discharges no river-water except where it is above the dikes—that is, in freshets. The river-bottom here is generally very hard, and does not yield readily to scour. This no doubt accounts for the small mean area given.

The object of the improvement is to maintain at every point a channel 180 feet wide, with not less than 15 feet depth at low tide. This requirement is fulfilled everywhere at present between Warwick Bar and Dutch Gap Canal, except for 1,100 feet in Kingsland's Reach. (On this reach the minimum depth is 13½ feet, the surface-width being 1,020 feet, while the mean width for several miles above and below is less than 700 feet.) Above Warwick Bar the river has this requirement at two points observed, viz, 1 at Richmond, just above the mouth of Gillie's Creek, which has 15 feet for 320 feet width, with a channel-depth of 17¾ feet, and 1 at the Quarry wharf, a short distance above Richmond Bar, where there are 15 feet for 250 feet width, and a channel-depth of 19½ feet. The requirements are nearly met in a few other sections. At the point just named the surface-width is 510 feet; at the other, 750 feet; but of this only 575 feet have over 2 feet depth. The section is in a sharp bend, with a radii of from 2,300 to 2,800 feet, and the convex shore is, as usual, quite shallow. There is no section between Warwick Bar and Richmond having the requirements with a surface-width of 800 feet. The cross-sections from Richmond to Warwick Bar, corresponding with tables 1 and 2, have been plotted to scale, and with these sections before me it does not seem probable that the required channel can be maintained above Warwick Bar with that surface-width without repeated dredging. The experience at Richmond Bar confirms this view, and is as follows: After the great flood of 1870, which, according to the letter of Captain Cunningham, reduced the depth on this bar to but little over 10½ feet, or, say, 7 feet at low tide, a channel 75 feet in width and 15 feet in depth at low tide was dredged out. In 3 years the bar was restored to the condition shown on Plate VII, according to the survey of 1874, the available depth being about 8½ feet at low tide, and the area 5,741 square feet. In 1874 a dike was built on the left side, (shown in Fig. 2,) which reduced the original width to about 900 feet. A channel 120 feet by 15 feet was then dredged. In this way the area was increased to 6,639 feet between the dike and the right shore. The next freshet (March, 1875, 10½ feet rise) reduced the depth to 11½ feet, and this depth was held for a very narrow belt; the area was reduced to 6,165 feet. The sides of the dredged channel were sloped off and the channel filled, as shown in the dotted line, Fig. 2, and the resulting area between the dike and the right bank was about 8 per cent. more than the area of 1874 *from shore to shore*. There remained a triangular-shaped trough to represent the dredged channel, 400 feet wide on top and running nearly to a point at bottom. In this I refer to the bar as a whole, and not especially to this particular cross-section.

In July, 1875, certain wing-dams and training-walls were constructed on the right bank, covering about 1,100 feet of the bar, which reduced the width uniformly to 775 feet. The first 300 feet of the work was a training-wall, built of loose stone taken from the channel at Goode's Rock; then, after an interval of 400 feet, a timber wing-dam; and after another similar interval, a second wing-dam. This second dam is shown on Fig. 3. The river-bed between the works on the two banks was carefully sounded at every 25 feet, the distances being measured by a graduated wire. The dams were

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Diagram showing Iow Water Slope between Rocketts Reef and Drums Bluff as measured and as calculated by Humphreys' and Abbot's formulae from mean areas with correction for bends

Full line is observed slope Broken line is calculated from mean areas on each section. Dotted line from mean areas on subsections of 1000 feet.

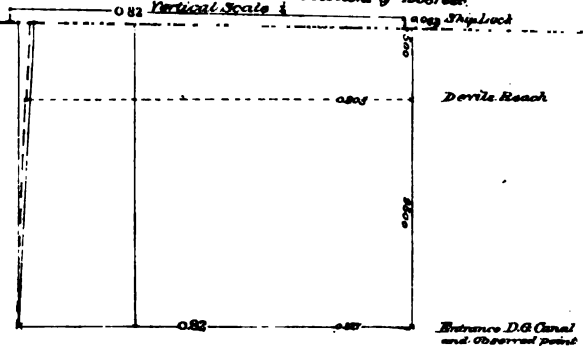

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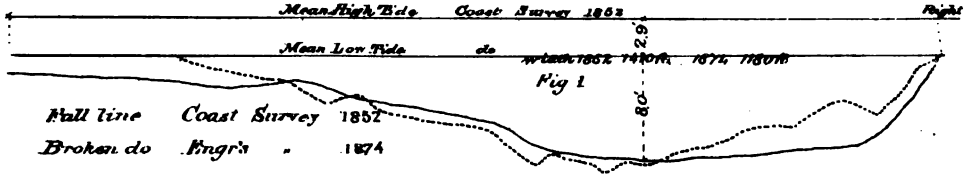
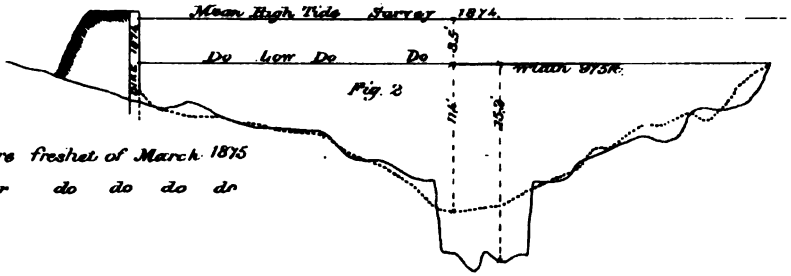
PLATE VII

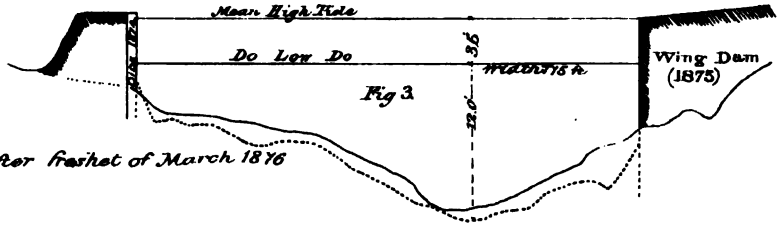
Cross Sections Richmond Bar

1852 - 1874 - 1875 - 1876

Horizontal Scale 300 feet Vertical 15 feet to 1 Inch







Areas at low water

No 1	Fig 1	Coast Survey	1852	6743	Sq ft
" 2	" "	Engineers "	1874	5741	" "
" 3	" 2	" "	"	6639	" " after dredging
" 4	" "	" "	1875	6165	" " " freshet
" 5	" 3	" "	1876	6270	" " " "

No 3 taken between dike on left bank and right shore

" 4 do do do

" 5 taken between dike on left bank and wing dam on right

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connected with the river-bank and were made to the level of high tide at the channel-end, and about 1 foot higher at the shore-end. From time to time afterward the soundings were retaken in the same way, until February, 1876, just before the freshet, which occurred in March. The action of the tides produced no marked effect. There was a tendency to fill up the triangular space and to a slight abrasion at other points, a tendency to round out the bed; but the area of the section remained essentially the same. There was no rise of the river in the interval exceeding 2 feet. In the latter part of March the river rose 8½ feet, and was above its usual stage for more than a week. The soundings were again taken April 4, and with the following result:

	Area between dike on left side and the right shore before wing-dams were built, July, 1875.	Area cut off by dams, &c.	Area between dike and jetty of 1876.	Scour.	Per cent. increase in water-way.
	Square feet.	*Square feet.*	*Square feet.*	*Square feet.*	
At end of training-wall	6,653½	58 75	6,947. 1	352. 6	4. 42
Between wall and dam No. 1	6,415	116. 25	6 539. 5	240. 5	2.
At wing-dam No. 1	6,375	353. 75	6,602. 5	581. 25	3. 57
At wing-dam No. 2	6,165	643. 75	6,270.	748. 75	1. 7
Average	6,402	.....	6,590.	.....	2. 9

The scour in this distance, of say 800 feet, was about 15,000 cubic yards. A line of soundings, taken about 500 feet below dam No. 2, showed a similar scour in the space between the dike and the line of the wing-dams; in the lee of the dams the water was shoaler than before. The site of dam No. 2 is on the line of soundings shown on Plate VII, and is a trifle below the present crest. The scour on the bar was quite uniform, tending still further to round off the bottom, and the triangular space representing the line of the dredged channel is nearly obliterated.

The history of this bar shows that dredging without a contraction in width is temporary in its effects; that the contraction of 1874, with dredging where the enlargement exceeded the area cut off by the dike, was followed by a deposit which nearly restored the area the river had before the dike was built, and that a further contraction in 1875, without dredging, was followed by a scour which left an area between the works about 9 per cent. greater than existed before they were begun. The area thus far seems to increase with the contraction in surface-width, or with the mean radius. This may be due to the lowering of the surface, or the averaging of the slope, (see disturbance in the slope on Richmond Bar on the diagram,) which would give a less velocity in some places, and make a larger area necessary to accommodate the discharge.

It will be noticed in the table showing the scour on Richmond Bar that the section between the end of the training-wall and the first wing-dam shows a less action than the remaining sections. I regard this as an indication that it will be found better to correct the channel ends of the dams with a low training-wall at some future time.

Similar effects to those described on Richmond Bar have resulted wherever contraction of width has been resorted to on this river, and encourage the belief that a uniform depth can be maintained by regulating its width according to its slope, and that this depth is at least 15 feet at low tide at Richmond, and a considerably greater depth below Warwick Bar.

I have mentioned that the river has the desired section near Richmond; it has it again just below Warwick Bar, and from that point to Dutch Gap Canal, with the exception mentioned in Kingsland's Reach.

Assuming that the river has the proper width at these points, if we connect them with gradually-widening lines, it is not unlikely that such lines would represent approximately the shores as they should be to produce and maintain a uniform depth. In the bends the width would be greater, and on straight reaches less. Such a line has been plotted on the several cross-sections of the river, and show in nearly every case that the excavation necessary to secure the channel with proper slopes in cross-section would just about fill the space cut off by the dikes. There is but one section on the part of the river in question that has a less width; it is at Rockett's Reef. These lines indicate that at Richmond Bar the river should not be over 550 or 600 feet wide. At some points the river-bed is too hard to yield readily to scour, and blasting or dredging is necessary; but generally the bed of the channel is of sand, where dredging, except to a limited extent, is unnecessary.

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It is often said that freshets bring down such quantities of sediment that the river-bed must fill up in time. That the river carries large amounts of solid matter is undoubted, and the amount is probably underrated by those who hold this view. But the channel-depths, both on the shoals and between them, are substantially the same now as the Coast Survey found them in 1852, except where the shoals have been improved. There has been a deposit in the river-bed below the head of the Dutch Gap Canal, and this might be expected *to the extent of the area of the canal*, ultimately, for this theory of the river required it. All this time sand and mud have been moving down the river. Even in August last, at a low stage of the river, the divers employed at Goode's Rocks found the sand moving on the bottom at ebb-tide. During the recent freshet I obtained a gallon of river-water, from near the surface, to ascertain the proportion of solid matter carried. The process of separating the solid matter from the water was not a very accurate one, and I give the result as an approximation only. After the sediment was separated it was dried in the sun, on a japanned plate, and then reduced to a powder. It was weighed, and then compressed firmly in a glass tube of small diameter, but over 2 feet long. The space occupied by a measured quantity of water in the tube had been previously marked on it, and the proportionate space occupied by the sediment gave its volume. It weighed 67 grains, and measured four-tenths of a cubic inch; its volume, as compared with the gallon, was as 1 to 564. Every 564 feet of water, then, carried a foot of solid matter. At an ordinary freshet of 10 feet rise there are at least 50,000 cubic feet of water passing Rockett's Reef every second, (this amount would require a section of *low-water width* and of the depth mentioned added to the mean depth, moving at a mean velocity of 2.86 miles per hour,) and assuming the proportion of sediment to be correct, there are in such a freshet 277,000 cubic yards of solid matter passing Rockett's in 24 hours. The whole cubic mass of water between Rockett's and Dutch Gap at low tide is about 25,000,000 of cubic yards, and if all the sediment stopped there, it would be completely filled in 100 such days. Leaving out the sediment carried at ordinary stages of the river, 20 years would block up the river to Dutch Gap, and 250 years certainly a very considerable distance below. Much of the sediment is deposited in eddies and shallows, and, during freshets, on submerged low ground; but it seems to me that the greater part must find its way to the ocean, aided by the constant action of the tides.

There must remain *a channel sufficient to carry the discharge of the river*, and this is why it remains as it was in 1852, and, so far as I can learn, as it was when visited by the white man. If there is any change, it is for the better.

The experience gained on the river makes it proper to modify the estimate for the completion of its improvement in some of its details. A much larger sum than before is estimated for dikes and rock-excavation, and a less amount for dredging. A larger percentage has been added for contingencies, as it will probably be necessary to connect the heads of wing-dams with walls, and to protect the shores of the river in places against abrasure. It is premature to express an opinion as to the extent that these will be needed. The estimate is for a channel 15 feet deep and 180 feet wide at mean low tide, and does not include the improvement of any shoal below Harrison's Bar, nor for any work on that bar except the mere widening and deepening the channel to correspond with that proposed above. Reasons have been given elsewhere in this report why all the shoals below Warwick Bar should have 18 feet depth at *low-water*, but no estimate is presented for the additional depth.

ESTIMATE FOR JAMES RIVER IMPROVEMENT, 1876, THE DEPTHS BEING TAKEN AT MEAN LOW TIDE.

Richmond Dock to Rockett's Reef:		
16,000 cubic yards dredging, at 50 cents	$8,000 00	
300 cubic yards rock, at $10	3,000 00	
		$11,000 00
Across Rockett's Reef:		
5,486 cubic yards of rock, at $10		54,860 00
Rockett's Reef to lower end of Drury's Island:		
100,000 cubic yards of dredging, at 50 cents	$50,000 00	
1,150 linear feet of timber-groins or wing-dams, at $1.75	2,012 50	
		52,012 50
Channel at Goode's Rocks:		
2,856 cubic yards of bowlders, at $9	25,704 00	
4,000 cubic yards of dredging, at 25 cents	1,000 00	
		26,704 00
Across Richmond Bar and Randolph's Flats:		
40,000 cubic yards of dredging, at 25 cents	10,000 00	
6,322 linear feet of timber-groins, at $1.75	11,063 50	
		21,063 50

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Across Warwick Bar:		
20,000 cubic yards of dredging, at 25 cents	5,000 00	
8,000 linear feet of dikes, at $3.50	28,000 00	
		33,000 00
Kingland's Reach:		
13,000 cubic yards of dredging, at 25 cents	3,250 00	
2,200 linear feet of dike, at $3.50	7,700 00	
		10,950 00
Dutch Gap Cut-Off:		
22,000 cubic yards of excavation, at 25 cents	5,500 00	
10,000 cubic yards of dredging, at 50 cents	5,000 00	
		10,500 00
At Aiken's, (no re-survey:)		
48,000 cubic yards of dredging, at 25 cents	12,000 00	
3,000 linear feet of dike, at $4	12,000 00	
		24,000 00
Across Harrison's Bar, (no re-survey:)		
1,500 cubic yards of dredging, at 50 cents		750 00
Contingencies, 20 per cent		48,968 00
Total		293,808 00

This estimate is submitted with the supposition that the prices of labor and materials will remain as at present, and that full appropriations are made, so as to avoid the increase of expense attending intermittent and incomplete operations.

I have had during the year the aid of Mr. George R. Talcott, assistant engineer, whose accuracy, industry, and skill in his profession have been of great value to the work. The city of Richmond has more than complied with the agreement made in April, 1874.

Very respectfully, your obedient servant,

H. D. WHITCOMB,
Assistant Engineer.

Col. WILLIAM P. CRAIGHILL,
Major Corps of Engineers, U. S. A.

CHARACTERISTICS OF JAMES RIVER, RICHMOND TO DUTCH GAP, 1874.

TABLE 1.—*First section, 19,500 feet, Richmond to Randolph's Flats.*

Station.	Near what point.	Surface-width, low-water.	Channel-depth, low-water.	Mean depth, low-water.	Sectional area.	Radius of curve, through center of mass.	Direction of curve.	Amount of curvature.	Remarks.
		Feet.	*Feet.*	*Feet.*	*Sq. feet.*	*Feet and deg.*		° ′	
1	Ship-lock	890	14¼	7.50	6,653	0	0	.....	
2	O. D. S. S. wharf	785	13½	7.51	5,981	0	0	.....	
3	James River S.S. wh'f	560	14½	13.42	7,516	0	0	.....	
4	Gillis's Creek	510	17½	14.67	7,482	Angle 20° 45′	Right	20 45	
5	Balto. S. S. wharf	580	13½	9.76	5,660	0	0	.....	
6	.....	580	16¼	10.33	6,094	1,200	Right	.....	
7	Marine railway	510	18½	10.83	5,522	2,200	Left	23 52	
8	Rockett's Reef	480	14½	9.85	4,728	0	.....	13 00	Rocky bottom.
9	Below brewery	570	16½	9.14	5,208	0	.....	.....	
10	Upper end D. I. dike	700	16½	7.36	5,150	0	.....	.....	
11	Upper end Drury's Island.	770	14	6.26	4,820	0	.....	.....	
12	Near Fire-brick wh'f	770	11½	6.56	5,052	5,400	Right	.....	
13	.....	765	11½	5.94	4,548	5,400	Right	.....	
14	C. & O. merch. wh'ves	800	16½	6.94	5,550	5,400	Right	.....	Increased by dredging.
15	....do	808	11½	7.76	6,289	5,400	Right	.....	
16	C. & O. coal-wharves	720	11½	8.28	5,963	5,400	Right	.....	
17	Almond Creek	740	11½	7.56	5,514	5,400	Right	.....	
18	.....	710	12	7.55	5,360	5,400	Right	37 20	
19	Lower end Dr. Island	740	11½	6.05	4,668	0	.....	.....	
20	.....	740	12½	7.95	5,883	2,800	Left	.....	
21	Lower end D. I. dike	670	15½	9.98	6,651	2,800	Left	20 30	
22	.....	710	15	9.66	6,857	2,300	Left	.....	
23	.....	715	15½	9.98	7,134	2,300	Left	.....	
24	Quarry-wharf	750	19¾	9.67	7,158	2,300	Left	37 30	
25	.....	800	16	7.16	5,725	5,600	Right	.....	Rocky bottom.
26	Goode's Rocks	770	14	7.16	5,512	5,600	Right	.....	Do.
27	.....	735	17	9.13	6,710	5,600	Right	.....	Do.
28	.....	810	16	8.40	6,802	5,600	Right	20 20	
29	.....	900	13½	7.96	7,163	0	.....	.....	

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TABLE I.—*First section*—Continued.

Station.	Near what point.	Surface - width, low-water.	Channel - depth, low-water.	Mean depth, low-water.	Sectional area.	Radius of curve, through center of mass.	Direction of curve.	Amount of curvature.	Remarks.
		Feet.	*Feet.*	*Feet.*	*Sq. feet.*	*Feet and deg.*		° ′	
30	Richmond Bar	1,160	9¾	4.66	5,404	11,200	Right	.....	
31	....do	1,200	9¾	4.81	5,775	11,200	Right	.....	
32	....do	1,170	9¾	4.84	5,663	11,200	Right	.....	
33	....do	1,060	10¼	5.62	5,956	11,200	Right	10 00	
34		940	14¾	7.01	6,588	13,200	Left	.....	
35		1,040	11¾	6.37	6,626	18,200	Left	.....	
36		1,060	9¾	7.11	7,532	18,200	Left	.....	
37	Randolph's Flats	1,040	11¾	6.52	6,783	18,200	Left	.....	
38	....do	1,020	9¾	6.54	6,671	18,200	Left	.....	
39	....do	1,000	10	6.37	6,368	18,200	Left	.....	
40	....do	960	10¼	7.03	7,020	18,200	Left	9 30	
	Averages	806.2	13.48	7.90	6,091	.....	.....	.....	

TABLE 2.—*Second section*, 18,500 *feet, Randolph's Flats to Drury's Bluff Landing.*

Station.	Near what point.	Surface - width, low-water.	Channel - depth, low-water.	Mean depth, low-water.	Sectional area.	Radius of curve, through center of mass.	Direction of curve.	Amount of curvature.
		Feet.	*Feet.*	*Feet.*	*Sq. feet.*	*Feet and deg.*		° ′
41		930	13¼	8.13	7,599	18,200	Left	.....
42		980	14¼	8.13	7,928	18,200	Left	.....
43		955	14¼	8.59	8,204	18,200	Left	.....
44		940	13¾	8.33	7,834	18,200	Left	.....
45	End of sec. map 2	920	14¼	8.55	7,870	18,200	Left	.....
46		910	15	9.12	8,300	18,200	Left	10 18
47		850	14¼	9.03	7,675	18,600	At 46¼° Right	.....
48		865	14	8.75	7,522	18,600	Right	.....
49		825	15½	10.43	8,608	18,600	Right	.....
50		810	14½	9.95	8,058	18,600	Right	.....
51	Warwick Bar	855	13½	9.75	8,340	18,600	Right	.....
52	.....do	840	17	10.63	8,933	18,600	Right	.....
53	.....do	875	15¼	10.33	9,034	18,600	Right	11 34
54	.....do	850	14¼	9.72	8,263	0	.....	.....
55	.....do	840	15	9.65	8,152	0	.....	.....
56*	.....do	860	17	11.25	9,671	6,000	Right	.....
57		840	17	11.19	9,400	6,000	Right	.....
58		710	20¾	13.96	9,914	6,000	Right	14 05
59		675	21¼	13.61	9,188	8,800	Right	.....
60		730	19	12.90	9,431	8,800	Right	.....
61		655	20	12.37	8,100	8,800	Right	.....
62		580	23	14.05	8,148	8,800	Right	.....
63		645	22¼	14.26	9,198	8,800	Right	16 15
64		640	21½	13.49	8,635	0	.....	.....
65		655	18	12.45	8,154	0	.....	.....
66		675	18½	12.99	8,679	0	.....	.....
67		695	17½	13.01	8,977	5,200	Left	.....
68		690	17	12.55	8,658	5,200	Left	11 00
69	Falling Creek	700	20	14.39	10,075	4,000	Left	.....
70		710	22	14.27	10,131	4,000	Left	.....
71		770	23	13.97	10,678	4,000	Left	.....
72	End of sec. map 3	775	23	12.05	9,338	4,000	Left	.....
73		715	25½	12.68	9,068	.....	Left	35 50
74		675	30	12.39	8,363	0	.....	.....
75		725	28	12.70	9,209	3,000	Left	.....
76		700	27	13.52	9,196	3,000	Left	.....
77		730	30¼	13.84	10,165	3,000	Left	19 00
	Averages	778.3	18.65	11.54	8,776			
	Maxima	980	30.25	14.39	10,678			
	Minima	580	13.25	8.13	7,522			

* At 56½ line of obstructions during civil war.

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TABLE 3.—*Third section, 19,000 feet, Drury's Bluff Landing to Grave-yard reach.*

Station.	Near what point.	Surface-width at low-water.	Channel-depth at low-water.	Mean depth at low-water.	Sectional area at low-water.	Radius of curve through center of mass.	Direction of curve.	Total curvature.
		Feet.	*Feet.*	*Feet.*	*Sq. feet.*	*Deg. and feet.*		° ′
78		540	33	17.40	9,395	3,000	Left	
79	Opposite Drury's Bluff	540	33½	18.84	10,134	3,000	Left	
80	....do	550	30½	17.32	9,535	3,000	Left	
81*		610	29	14.39	8,760	3,000	Left	47 30
82		605	34½	20.66	12,501	4,400	Left	
83		535	37	22.46	12,016	4,400	Left	
84		450	31½	19.72	8,875	4,400	Left	
85		565	27½	21.38	12,083	4,400	Left	
86		560	28½	18.90	10,583	At 85½° 0		22 45
87	Big Wilton Creek	600	26½	16.31	9,788	0		
88		620	23½	15.52	9,625	0		
89	Little Wilton Creek	640	23½	17.00	10,880	0		
90		670	22½	17.15	11,494	1,600	Right	
91		680	29½	16.99	11,550	1,600	Right	
92		660	38½	17.97	11,876	1,600	Right	
93		570	42½	15.68	8,935	1,600	Right	71 20
94		545	38½	22.21	12,103	0		
95	Chaffin's Bluff	515	35½	20.05	10,326	0		
96	....do	560	32½	19.62	10,988	0		
97		620	27½	17.26	10,703	At 96½° 5,400	Right	
98		600	26	16.98	10,188	5,400		
99		610	26½	16.96	10,349	0		13 20
100		630	25½	17.46	11,011			
101		625	23½	16.65	10,409	4,800	Right	
102		680	22½	15.29	10,337	0		6 00
103		740	20½	13.64	10,099	0		
104		655	20	13.28	8,696	0		
105		760	19½	14.06	10,619	0		
106	Willis's Wharf	740	19½	13.95	10,333	1,500	Left	
107		760	20	14.58	11,080	0		19 15
108	Kingsland's Creek	690	29	15.37	10,603	1,900	Left	
109		710	31	16.38	11,684	2,800	Left	15 00
110		700	24½	15.12	10,588	2,800	Left	
111	Grave-yard reach	780	21	12.74	9,975	2,800	Left	
112	....do	920	16	9.60	8,830	4,000	Right	30 30
113	....do	1,020	14½	8.72	8,900	4,000	Right	
114	....do	980	18½	12.13	11,884	2,600	Right	14 20
115		890	24	12.70	11,307	1,500	Right	10 00
	Averages	661.4	27.01	16.38	10,500			
	Maxima	1,020	42.25	22.46	12,501			
	Minima	450	14.25	8.72	8,696			

*Just below line of obstructions during civil war.

TABLE 4.—*Fourth section, 18,500 feet, Grave-yard reach to Dutch Gap Cut-off.*

Station.	Near what point.	Surface-width at low-water.	Channel-depth at low-water.	Mean depth at low-water.	Sectional area at low-water.	Radius of curve through center of mass.	Direction of curve.	Total deflecture.
		Feet.	*Feet.*	*Feet.*	*Sq. ft.*	*Deg. and feet.*		° ′
116		580	36	23.47	13,510	1,500	Right	
117		545	45	24.08	13,125	1,500		
118		620	35	18.68	11,592	0		57.15
119		690	25	14.18	9,785	0		
120		700	22	13.98	9,738	0		
121		810	21	13.59	11,005	1,600	Left	
122		810	22	13.70	11,093	0		17.50
123		675	27	18.11	12,225	1,000	Left	
124		570	35	21.25	12,112	1,000		
125	Devil's Reach	480	43	22.91	10,997	1,000		
126	....do	440	46	29.57	13,011	0		86.00
127	....do	480	41	23.48	11,270	0		
128	....do	570	33	20.07	11,438	At 127½° 2,400	Left	10.13

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TABLE 4.—*Fourth section, &c.*—Continued.

Section.	Near what point.	Surface-width at low-water.	Channel-depth at low-water.	Mean depth at low-water.	Sectional area at low-water.	Radius of curve through center of mass.	Direction of curve.	Total deflection.
		Feet.	*Feet.*	*Feet.*	*Sq. ft.*	*Deg. and feet.*		° ′
129	Devil's Reach	590	31	20.19	11,912	0	.....	12.00
130	....do	560	42	20.15	11,285	500	Left	.....
131	....do	540	39	33.36	12,617	At 130½° 1,500	Left	19.08
132	....do	480	36	21.53	10,335	1,500	.....	.....
133*	....do	470	37	24.58	11,550	At 133½° 1,500	Right	36.00
134	....do	465	43	28.67	13,332	1,500	.....	36.00
135	....do	505	44	24.22	12,230	At 134½° 500	Right	36.00
136	.....	.....	.....	.....	.....	At 135½° 1,600	Right	56.23
137	.....	590	34	21.61	12,750	3,200	Right	31.13
138	.....	565	37	21.60	12,206	3,200	Right	.....
139	.....	555	37	21.22	11,775	3,200	Right	.....
140	.....	600	38	19.61	11,763	3,200	Right	.....
141	.....	585	32½	23.83	13,938	10,000	Right	36.00
142	.....	600	29	19.44	11,663	10,000	Right	.....
143	.....	670	30	19.44	12,435	2,300	Right	5.50
144	.....	630	30	16.58	10,450	2,300	.....	.....
145	.....	575	37	19.39	11,150	0	.....	25.00
146	Cox's Wharf	510	35	21.81	11,167	0	.....	.....
147	.....	500	34	19.25	9,625	At 146½° 1,200	Right	.....
148	.....	500	36	21.60	10,800	0	.....	39.47
149	.....	490	38	19.80	8,962	3,000	Right	.....
150	.....	475	36½	21.60	9,730	3,000	Right	.....
151	.....	510	39	23.30	11,885	3,000	Right	.....
152	Opposite Dutch Gap Cut-off	530	35	22.40	11,330	3,000	Right	38.20
	Averages	568½	32.1	20.9	11,549			
	Maxima	810	46	28.67	13,938			
	Minima	440	21	13.59	8,962			

* Ledge of sandstone on right bank between 133 and 134.

TABLE 5.—*Fifth section, 29,000 feet, upper to lower end of Dutch Gap Canal by river.*

Section.	Near what point.	Surface-width at low-water.	Channel-depth at low-water.	Mean depth at low-water.	Sectional area at low-water.	Radius of curve through center of mass.	Direction of curve.	Total deflection.
		Feet.	*Feet.*	*Feet.*	*Sq. ft.*	*Deg. and feet.*		° ′
153*	Upper end of Dutch Gap Canal	540	30	22.3	11,287	.....	.....	.....
154	.....	530	31	18.4	9,287	.....	.....	.....
155	.....	570	32	18.4	10,160	.....	.....	.....
156	.....	610	29	17.9	10,179	.....	.....	.....
157	.....	540	30	18.4	8,412	.....	.....	.....
158	.....	580	26	18.6	10,340	.....	.....	.....
159	.....	610	24½	17.3	10,265	.....	.....	.....
160	.....	655	22	16.2	9,567	.....	.....	.....
161	.....	665	19½	15.8	10,342	.....	.....	.....
162	.....	660	17½	15.2	9,908	.....	.....	.....
163	.....	720	17½	15.1	10,668	.....	.....	.....
164	.....	730	19	14.1	10,032	.....	.....	.....
165	.....	790	18½	14.0	10,617	.....	.....	.....
166	.....	765	17½	12.8	9,641	.....	.....	.....
167	.....	750	17	12.8	9,600	.....	.....	.....
168	.....	840	15½	12.5	10,201	.....	.....	.....
169	.....	940	17½	12.1	11,082	.....	.....	.....
170	.....	1,000	20	11.1	11,113	.....	.....	.....
171	.....	940	28	11.3	10,243	.....	.....	.....
172	.....	780	39	15.2	12,245	.....	.....	.....
173	.....	500	49	29.2	14,612	.....	.....	.....
174	.....	485	48	32.9	15,102	.....	.....	.....
175	Osborne's	506	44	28.4	13,064	.....	.....	.....
176	.....	570	38	23.6	13,000	.....	.....	.....
177	.....	540	39	22.2	11,605	.....	.....	.....
178	.....	570	38	20.8	11,510	.....	.....	.....
179	.....	625	38	20.4	12,256	.....	.....	.....

14.32 miles below ship-lock.

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TABLE V.—*Fifth section, 29,000 feet, &c.*—Continued.

Station.	Near what point.	Surface-width at low water.	Channel-depth at low water.	Mean depth at low-water.	Sectional area at low-water.	Radius of curve through center of mass.	Direction of curve.	Total deflection.
		Feet.	*Feet.*	*Feet.*	*Sq. ft.*			° ′
180		570	41	21.5	12,306			
181		450	100	56.1	25,250			
182		400	74	43.9	17,570			
183		500	58	36.0	16,000			
184		780	23	15.8	12,330			
185	Trent's Reach	1,100	18	10.9	12,076			
186	do	1,240	15	9.4	11,498			
187	do	1,450	17½	8.1	11,850			
188	do	1,450	11½	7.8	11,375			
189	do	1,525	13	7.0	10,563			
190	do	1,600	14	6.9	11,113			
191	do	1,565	19	8.5	13,195			
192	do	1,470	16	8.4	12,248			
193	do	1,300	14	10.6	13,813			
194		750	41	20.1	15,075			
195		590	42	24.5	13,488			
196		600	38	22.3	13,425			
197		600	37	23.3	13,875			
198		650	29	21.0	13,675			
199		690	26	19.1	12,502			
200		760	22	17.1	12,890			
201		840	18½	15.5	12,527			
202		910	18	14.0	12,603			
203		950	17	13.7	13,063			
204		1,000	17	12.7	12,725			
205*	Opposite lower end Dutch Gap Canal.	970	38	16.8	15,969			
206		870	34	17.1	14,555			
207		690	44	24.3	16,393			
208		630	43	24.6	14,850			
209		560	39	27.5	14,103			
210		570	37	24.5	13,538			
	Averages	790	30	18.55	12,462			

*19.3 miles below ship-lock; 5 miles saved by canal.

TABLE 6.—*Summary of the preceding tables.*

	Section No. 1.	Section No. 2.	Section No. 3.	Section No. 4.	Section No. 5.
Greatest width at low-water	1,200	980	1,020	810	1,600
Least width at low-water	480	580	450	440	400
Mean width at low-water	806.2	778.3	661.4	568.5	790
Greatest channel depth	19½	30½	42½	46	100
Least channel depth	9½	13½	*14½	21	11½
Mean channel depth	13.50	18.65	27.01	32.10	30
Greatest mean depth	14.67	14.39	22.46	28.70	56.1
Least mean depth	4.81	8.13	8.72	13.60	6.9
Average mean depth	7.90	11.54	16.38	20.90	18.55
Greatest sectional area	7,532	10,678	12,501	13,938	25,250
Least sectional area	4,548	7,532	8,696	8,962	8,412
Mean sectional area	6,091	8,776	10,500	11,549	12,462

*On section taken. One line of soundings on No. 3 has minimum channel depth of 13½ feet.

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TABLE 7.—*Mean depths and areas corresponding to various surface widths.*

Width.	Section No. 1.		Section No. 2.		Section No. 3.		Section No. 4.		Section No. 5.	
	Mean depths.	Areas.	Mean depths.	Areas.	Mean depths.	Areas.	Mean depths.	Areas.	Mean depths.	Areas.
From 440 to 500 feet	9.85	4,728	.....	.....	19.72	8,875	24.0	11,023	44.30	19,307
From 500 to 550 feet	12.75	6,502	.....	.....	20.19	10,775	22.5	11,597	24.99	12,088
From 550 to 600 feet	10.66	6,120	14.05	8,148	18.58	10,425	21.3	12,208	22.42	12,313
From 600 to 650 feet	.....	.....	13.88	8,917	16.88	10,421	18.6	11,365	20.97	12,474
From 650 to 700 feet	9.98	6,651	12.91	8,588	16.01	10,759	17.2	11,482	18.60	12,065
From 700 to 750 feet	8.17	5,918	13.53	9,649	14.77	10,624	14.0	9,785	14.60	10,350
From 750 to 800 feet	7.18	5,512	13.02	10,008	13.79	10,588	13.6	11,049	15.40	11,757
From 800 to 850 feet	7.56	6,093	10.37	8,630	.....	.....	.....	.....	15.03	12,429
From 850 to 900 feet	7.50	6,653	9.81	8,414	12.70	11,307	.....	.....	12.47	11,309
From 900 to 950 feet	7.48	6,875	8.53	8,001	9.60	8,830	.....	.....	15.25	14,566
From 950 to 1,000 feet	7.03	7,020	8.36	8,019	12.13	10,392	.....	.....	.....	.....
From 1,000 to 1,050 feet	6.45	6,615	.....	.....	8.72		.....	.....	11.90	11,916
From 1,050 to 1,100 feet	6.36	6,744	.....	.....	.....	.....	.....	.....	.....	.....
From 1,100 to 1,150 feet	.....	.....	.....	.....	.....	.....	.....	.....	10.90	12,076
From 1,150 to 1,600 feet	.....	.....	.....	.....	.....	.....	.....	.....	8.34	11,975

F 12.

IMPROVEMENT OF THE APPOMATTOX RIVER, VIRGINIA.

Under the appropriation of March 3, 1875, of $30,000, a contract was made July 1, 1875, with Mr. G. H. Ferris for dredging, the object being to remove as soon as possible the worst impediments to navigation. The annual appropriations have continued to be but little in excess of the sum necessary for reparations, after the completion of a definite plan of improvement. In consequence, the annual process of operation has been chiefly an effort, by resorting to the use of the dredge promptly, to remove the obstacles to navigation to be annually expected in the unfinished state of the river, and next, or simultaneously, by the use of the remainder of the available funds to make a step forward as great as possible in the plan of permanent improvement.

Under the contract mentioned above, about 55,000 cubic yards of material were excavated from the channel, as shown in more detail in the report attached hereto of Mr. H. D. Bird. The most of this material has been redeposited in the deeper portions of the river below, a procedure well known to be vicious, imposed by the necessity of quickly and with small means attaining the results required by the needs of commerce.

Under the second contract, dated December 31, 1875, an average widening of about 20 feet to the Puddledock Channel has been in progress, which is nearly completed at the date of this report. This channel will then be about 100 feet wide at high-water, and 10 feet deep at mean low-water.

Money statement.

Amount available July 1, 1875	$39,058 03
Amount expended during fiscal year ending June 30, 1875	31,444 86
Amount available July 1, 1876, including $1,331.26 due on contracts	7,613 17
Amount appropriated by act approved August 14, 1876	30,000 00
Amount (estimated) required for completion of existing project, (see last annual report)	113,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	83,000 00

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DREDGING APPOMATTOX RIVER, VIRGINIA.

Proposals at 1.5 *p. m., December* 20, 1875.

Number.	Name.	Residence.	Price per cubic yard for material scowed away.	Price per cubic yard for material deposited on side of cut.
			Cents.	*Cents.*
1	G. H. Ferris	Brooklyn, N. Y	15 9-10	.....
2	Green & Saterlee	New York City, N. Y	62	54
3	E. R. Seward	Albany, N. Y	25	40
4	F. B. Colton	Philadelphia, Pa	22	24
5	C. J. De Graw	Volney, N. Y	20	20
6	R. T. Hieston	Washington, D. C	19⅞	23⅞
7	H. E. Culpepper	Portsmouth, Va	25½	29½
8	M. F. Brainard	Albany, N. Y	19⅝	.....

Contract awarded to Mr. G. H. Ferris, at 15 9-10 cents per cubic yard.

REPORT OF MR. H. D. BIRD, ASSISTANT ENGINEER.

PETERSBURG, VA., *June* 1, 1876.

COLONEL: I have the honor to submit my report of the progress and condition of this work for the twelve months ending May 31, 1876.

In my last report I divided the improvement into 3 parts, as more convenient for reference, and stated that up to that date the amount of dredging done at Government expense was as follows:

	Feet long.	Cubic yards.
South Channel	10,800	220,094.46
Puddledock Channel	9,200	113,637.61
Petersburg Channel	10,500	158,520.65
Total	30,500	492,252.72

With this dredging we obtained a channel 40 to 80 feet wide at bottom and 10 feet deep at low-water, where there had been only 4½ feet before.

It is proper to add, in this connection, the information that the South Channel is an old natural channel of the river, and Puddledock Channel is a new cut made through a swamp flooded in freshets, connecting it with the Petersburg Channel, the only part of the old river used in the improvement.

The dredging by Government was commenced September 10, 1871, and has been prosecuted ever since as far as the appropriations made by Congress would allow. On the 21st of June, 1875, you received proposals for dredging 52,000 cubic yards of bars formed since the commencement of the work, but mostly in the Petersburg Channel, (as you will see below,) by the large spring freshets of that year. The work was allotted to Mr. G. H. Ferris, of Brooklyn, who was the lowest bidder. He commenced it January 17, 1875, and completed the work January 10, 1876. The amount of it was as follows:

	Yards.
In South Channel	12,002.73
In Puddledock Channel	3,541.00
In Petersburg Channel	34,715.93
In filling old piling	4,649.74
Total work done	54,909.40

The filling of old piling was a necessity that arose during the progress of the work the material removed from bars was 50,259.66 yards.

On the 20th of December, 1875, you received proposals for dredging about 100,000 cubic yards from the side of Puddledock cut, "to widen it 20 feet." Mr. Ferris was again the successful bidder. He began the work January 11, and up to the 1st of this month he had removed 74,360.65 yards. It will take him about 2 months more to complete the contract. The cut will then be 60 feet wide at bottom, about 100 feet at high-water, and 10 feet deep at low-water. The total dredging done during the last 12 months was 129,270 yards. The result of the operation for improving the river

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thus far shows that vessels drawing from 10 to 10½ feet water have been able to reach the city wharves, whereas before the dredging was begun those drawing over 7½ feet had to be lightened to enable them to come up. By reducing a few bars, formed by recent freshets, vessels drawing 12 feet can ascend to Petersburg.

By the account of material removed from bars, you will see that the greater part was taken from the Petersburg Channel. These bars will continue to form until the works you estimated for to contract the channel are constructed. But this cannot be done effectually with the limited amount of appropriations made by Congress. It is greatly to be regretted that they were not larger, inasmuch as they would have given the city the full benefit of the improvement sooner, and have saved a part of the cost of dredging the bars.

The city corporation has up to this time dredged a considerable quantity of sand from the harbor, and when the works are completed in the river the benefit the citizens will derive from the increased commerce will make it their interest to keep the bars dredged out.

The improvement of the Appomattox River, though apparently a local one, is in reality of national importance. Before the war all the through transportation of the great line of railroad through Petersburg to the West and Southwest, with its ramifications through Tennessee and a part of Georgia, Alabama, and Mississippi, down to New Orleans, was shipped at the port of Petersburg, City Point, at the junction of the Appomattox with the James. That transportation has now grown to gigantic dimensions, but owing to extraneous causes, and not to any fault of the port, it is now carried by rail, eighty miles farther, to Norfolk for shipment. With the completion of the Appomattox improvement and the construction of proper wharfage, and other facilities for transporting freight, there is no good reason why this transportation should not be restored to its former route.

The whole country using this railroad-line is now taxed to support the 80 miles of road between Petersburg and Norfolk. In my report to you of 1872,* I ascertained from the railroad report the amount that the through-freight paid the company that year. It was $213,313. It must have increased materially since. This great tax is still a yearly one on the internal trade of the country, and it can be saved by the completion of the Appomattox River improvement.

Respectfully, your obedient servant,

H. D. BIRD,
Assistant Engineer.

Col. WM. P. CRAIGHILL,
Major Corps of Engineers, U. S. A.

F 13.

IMPROVEMENT OF THE CAPE FEAR RIVER, NORTH CAROLINA.

The channel behind the Horseshoe Shoal, near New Inlet, has been increased in dimensions by dredging.

The width has been brought from 100 to about 190 feet, and the depth at low-water from 9 to about 12 feet. This work was completed in the latter part of April, 1876, under contract by Curtis & Fobes.

On the 6th of August, 1875, proposals were received for a structure the object of which was to contract the outflow at New Inlet. Several plans were suggested of accomplishing this result in part or in whole. The amount of funds available limited the work to a structure made of pine logs, brush, and stone, taking the form of an apron on the bottom of the inlet 4 feet high, with a base varying from 40 to 70 feet.

A contract was made August 25, 1875, with Bangs & Dolby. They worked energetically and successfully, and completed the apron from the end of the crib-jetty at Federal Point to Zeke's Island, a distance of over 4,000 feet, between October 7, 1875, and June 2, 1876. The construction of this apron and the dredging of the channel behind the Horseshoe Shoal were intended to be supplementary to each other, and together form an important part of the plan of improvement which looks

* Report of Chief of Engineers, 1872-'73, page 693.

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to an increased depth of water in the old mouth of the river at the Bald-head entrance, by partial or entire closure of New Inlet, and the consequent diversion of much water to the old mouth.

With the same object of hastening the deepening of the Bald Head Bar, the suction-dredge Woodbury was operated there until the condition of her boiler and machinery required her withdrawal, at the end of January, 1876. She has since been idle, as funds could not be used for her repair.

The river was obstructed during the late civil war by the confederate authorities at a point about 3 miles below the city of Wilmington. The removal of these obstructions was begun in July, 1875, and completed over a length of about 1,500 feet in August, so as to give a depth of 12 feet over them at low-water, which is the minimum expected to be attained at this stage of the improvement from Wilmington to the ocean over all obstructions to navigation.

After completion of the Horseshoe Channel, one dredge was engaged a few days at the shoal near Campbell's Island, and clearing the channel near the east jetty next below Brunswick River. The depth aimed at and attained here, as elsewhere, has been about 12 feet at low-water, equal to 16 or 16½ feet at high-water.

Surveys have been continued under the special charge of Mr. C. P. Bolles, having for their object such a delineation of the hydrography and topography as will enable comparison to be made of the present with the former condition of the river, as well as to detect any points where further improvement may be needed, and to give a basis upon which to predicate the estimate of the cost of any work which may in the future be required.

Since January, 1876, the immediate supervision of this improvement has been committed to Mr. H. Bacon, succeeding Capt. C. B. Phillips, who has been in charge from 1872, inclusive.

Reference is requested to the report for the year of Mr. Bacon, hereto appended, as well as to the historical sketch prepared by Captain Phillips, at my request.

Money statement.

Amount available July 1, 1875	$211,287 43
Amount expended during fiscal year ending June 30, 1876	188,564 71
Amount available July 1, 1876, including $9,444.46 due on contracts	22,722 72
Amount appropriated by act approved August 14, 1876	132,500 00
Amount (estimated) required for completion of existing project, (see last annual report)	210,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	77,500 00

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Statement of the principal articles of produce and manufacture exported from the port of Wilmington, N. C., for the year ending December 31, 1875, as compiled from the reports of the Daily Journal, and compared with those for the years 1874, 1873, and 1872.

COASTWISE.

Destination.	Bales of cotton.	Casks of spirits of turpentine.	Barrels of rosin.	Barrels of tar.	Barrels of crude turpentine.	Barrels of pitch.	Lumber.	Shingles.	Juniper bolts.
New York	43,746	8,591	143,029	14,745	7,150	250	131,023	1,585,250	21,787
Baltimore	5,645	8,292	27,652	7,039	250	2,085	1,085,138	.....	.....
Philadelphia	3,691	1,051	12,037	2,230	433	1,040	792,906	1,435,350	55,102
Boston	41	602	4,210	6,426	125	532	.....	309,600	.....
Bath	.....	17	10	100	.....	87	636,154	.....	.....
Richmond	.....	.....	.....	.....	.....	.....	350,811	.....	.....
Thomaston	.....	.....	.....	.....	.....	.....	342,065	.....	.....
Bucksport	.....	.....	.....	.....	.....	.....	181,321	.....	.....
Providence	.....	.....	.....	.....	.....	.....	255,000	.....	.....
Burlington	.....	.....	.....	.....	.....	.....	141,650	.....	.....
Total coastwise, 1875	53,123	18,559	186,938	30,540	7,958	3,994	3,916,066	3,330,200	76,889
Total coastwise, 1874	55,621	42,838	309,959	47,829	14,945	7,316	9,998,295	5,432,408	110,476
Total coastwise, 1873	35,016	42,283	342,499	41,030	14,520	8,244	12,597,597	3,960,580	.....
Total coastwise, 1872	46,747	59,410	423,394	32,368	11,558	7,072	16,553,746	3,323,795	.....

FOREIGN.

Liverpool	15,839	5,708	38,460	9,034	339	.....	.....	.....	.....
London	.....	25,362	38,457	.....	.....	.....	.....	.....	.....
Amsterdam	1,075	.....	4,196	.....	.....	.....	.....	.....	.....
Rotterdam	.....	6,193	48,492	.....	.....	.....	.....	.....	.....
Bristol	.....	6,119	20,844	10	.....	.....	.....	.....	.....
Granton	.....	.....	18,222	.....	.....	.....	.....	.....	.....
United Kingdom	.....	1,727	225	.....	.....	.....	.....	.....	.....
Antwerp	.....	7,398	21,612	.....	.....	.....	.....	.....	.....
Dordrecht	.....	.....	2,500	.....	.....	.....	.....	.....	.....
Hamburg	1,226	3,775	33,005	.....	.....	.....	.....	.....	.....
Greenock	.....	.....	.....	2,121	.....	.....	.....	.....	.....
Stettin	.....	.....	10,180	.....	.....	.....	.....	.....	.....
Glasgow	.....	6,075	39,072	1,200	.....	.....	.....	.....	.....
Santiago de Cuba	.....	.....	.....	.....	.....	.....	134,385	.....	.....
Hull	.....	200	3,182	3,881	.....	.....	.....	.....	.....
Cape Haytien	.....	.....	7	2	.....	2	65,000	150,000	.....
Cardenas	.....	1	53	109	.....	90	630,368	.....	.....
Aux Cayes	.....	.....	.....	.....	.....	.....	161,000	238,400	.....
Cork or Falmouth	.....	14,095	800	.....	.....	.....	.....	.....	.....
Ponce	.....	.....	.....	.....	.....	.....	468,551	30,000	.....
Hayti	.....	.....	.....	.....	.....	.....	961,149	336,000	.....
Belfast	.....	100	4,056	.....	.....	.....	.....	.....	.....
Jacmel	.....	.....	.....	.....	.....	.....	227,760	70,000	.....
Martinique	.....	.....	.....	.....	.....	.....	182,518	.....	.....
St. Pierre	.....	.....	.....	.....	.....	.....	322,000	.....	.....
Bahamas	.....	.....	.....	.....	.....	.....	38,000	330,000	.....
Demerara	.....	.....	.....	75	.....	.....	548,678	27,000	.....
Georgetown, Yucatan	.....	.....	.....	75	.....	.....	.....	.....	.....
Surinam	.....	.....	.....	.....	.....	50	133,000	.....	.....
Cronstadt	.....	.....	3,600	.....	.....	.....	.....	.....	.....
Laguayra	.....	.....	310	.....	.....	.....	383,606	.....	.....
Porto Rico	.....	.....	5	12	.....	5	969,606	215,600	.....
Matanzas	.....	24	101	50	.....	.....	47,828	.....	.....
Barcelona	.....	.....	1,075	.....	.....	.....	.....	.....	.....
Port au Prince	.....	.....	.....	.....	.....	.....	631,092	462,000	.....
Havana	.....	5	998	50	.....	35	.....	.....	.....
Newcastle	.....	600	1,060	.....	.....	.....	.....	.....	.....
Bremen	.....	500	2,000	.....	.....	.....	.....	.....	.....
Total foreign, 1875	18,140	77,882	291,812	16,619	339	182	5,904,541	1,859,000	.....
Total foreign, 1874	4,697	83,087	379,330	20,799	650	167	4,231,030	3,087,805	.....
Total foreign, 1873	34	88,953	347,652	4,296	735	180	6,920,171	2,378,256	.....
Total foreign, 1872	707	77,969	196,666	4,918	950	275	6,710,436	1,534,439	.....

GRAND TOTALS.

Total coastwise and foreign, 1875	71,263	96,441	478,850	47,159	8,297	4,176	9,820,607	5,189,200	76,889
Total coastwise and foreign, 1874	67,518	125,925	689,289	68,619	15,595	7,483	14,229,325	8,520,213	110,476
Total coastwise and foreign, 1873	39,650	131,236	690,151	45,326	15,255	8,164	19,517,768	6,338,836	.....
Total coastwise and foreign, 1872	47,454	137,379	629,110	37,287	12,508	7,347	23,264,152	4,868,234	.....

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Statement of the principal articles of produce and manufacture exported from the port of Wilmington, N. C., for the year ending December 31, 1875, *&c.*—Continued.

COASTWISE—Continued.

Destination.	Bushels of pea-nuts.	Bushels cow-peas.	Bundles of shooks.	Bundles of paper-stock.	Packages of merchandise.	Bales of yarn.	Bales of sheeting.	Casks of kaolin.	Cases of spirits.	Casks of tar.	Bales of wool.	Barrels bees'-wax.
New York	16,937	.....	7,496	825	1,122	25	920	703	15	....	28	42
Baltimore	20,083	16	4	914	426	907	812	....	210	770	54	2
Philadelphia	4,118	1,324	.....	102	171	328	252	36	....	....	16	....
Boston	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Bath	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Richmond	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Thomaston	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Bucksport	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Providence	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Burlington	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Total coastwise, 1875	46,138	1,340	7,430	1,841	1,719	1,260	1,984	739	225	770	98	44
Total coastwise, 1874	33,562	825	4,714	332	2,353	1,095	2,375	127	376	717	138	285
Total coastwise, 1873	.....	.....	.....	.....	.....	497	2,356	....	....	....	....	....
Total coastwise, 1872	.....	.....	.....	.....	.....	48	1,218	....	....	....	....	....

FOREIGN—Continued.

Liverpool	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
London	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Amsterdam	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Rotterdam	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Bristol	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Granton	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
United Kingdom	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Antwerp	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Dordrecht	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Hamburg	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Greenock	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Stettin	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Glasgow	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Santiago de Cuba	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Hull	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Cape Haytien	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Cardenas	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Aux Cayes	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Cork or Falmouth	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Ponce	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Hayti	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Belfast	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Jacmel	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Martinique	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
St. Pierre	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Bahamas	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Demerara	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Georgetown, Yucatan	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Surinam	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Cronstadt	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Laguayra	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Porto Rico	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Matanzas	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Barcelona	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Port au Prince	5,000	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Havana	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Newcastle	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Bremen	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Total foreign, 1875	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Total foreign, 1874	33,565	.....	.....	.....	.....	26	3	....	....	....	....	....
Total foreign, 1873	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....
Total foreign, 1872	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	....

GRAND TOTALS—Continued.

Total coastwise and foreign, 1875	41,138	1,340	7,430	1,841	1,719	1,266	1,984	739	225	770	98	44
Total coastwise and foreign, 1874	43,562	825	2,714	332	2,353	1,121	2,378	127	376	717	138	285
Total coastwise and foreign, 1873	.....	.....	.....	.....	.....	497	2,356	....	....	....	....	....
Total coastwise and foreign, 1872	.....	.....	.....	.....	.....	48	1,258	....	....	....	....	....

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Statement of the principal articles of produce and manufacture exported from the port of Wilmington, N. C., for the year ending December 31, 1875, *&c.*—Continued.

COASTWISE—Continued.

Destination.	Bundles of hides.	Bales of rags.	Tons of iron and ores.	Railroad cross-ties.	Barrels of eggs.	Empty kegs, barrels, and hogsheads.	Casks of rice.	Bricks.	Barrels vegetables.	Bundles of roots and herbs.	Hogsheads of pipe-staves.
New York	54	20	508	.....	48	62	151	.....	34	164	....
Baltimore	210	129	45	.....	1	434	6	.....	27	60	24
Philadelphia	6	97	111	.....	16	854	....	.....	2	....	....
Boston	.....	.....	.....	.....	.....	.....	....	.....	.....	....	....
Bath	.....	.....	.....	.....	.....	.....	....	.....	.....	....	....
Richmond	.....	.....	.....	.....	.....	.....	....	.....	.....	....	....
Thómaston	.....	.....	.....	.....	.....	.....	....	.....	.....	....	....
Bucksport	.....	.....	.....	.....	.....	.....	....	.....	.....	....	....
Providence	.....	.....	.....	.....	.....	.....	....	.....	.....	....	....
Burlington	.....	.....	.....	.....	.....	.....	....	.....	.....	....	....
Total coastwise, 1875	270	246	664	.....	65	1, 350	157	.....	63	224	24
Total coastwise, 1874	3, 570	399	8, 741	.....	120	3, 111	298	.....	...	....	....
Total coastwise, 1873	.....	...	.....	.....	.....	.....	....	.....	...	....	....
Total coastwise, 1872	.....	.....	.....	.....	.....	.....	....	.....	.....	....	....

FOREIGN—Continued.

Liverpool	.....	...	.....	.....	...	.....	....	.....	...	....	....
London	.....	...	.....	.....	...	.....	....	.....	...	....	....
Amsterdam	.....	...	.....	.....	...	.....	....	.....	...	....	....
Rotterdam	.....	...	.....	.....	...	.....	....	.....	...	....	....
Bristol	.....	...	.....	.....	...	.....	....	.....	...	....	....
Granton	.....	...	.....	.....	...	.....	....	.....	...	....	....
United Kingdom	.....	...	.....	.....	...	.....	....	.....	...	....	....
Antwerp	.....	...	.....	.....	...	.....	....	.....	...	....	....
Dordrecht	.....	...	.....	.....	...	.....	....	.....	...	....	....
Hamburg	.....	...	.....	.....	...	.....	....	.....	...	....	....
Greenock	.....	...	.....	.....	...	.....	....	.....	...	....	....
Stettin	.....	...	.....	.....	...	.....	....	.....	...	....	....
Glasgow	.....	...	.....	.....	...	.....	....	.....	...	....	....
Santiago de Cuba	.....	...	.....	.....	...	.....	....	.....	...	....	....
Hull	.....	...	.....	.....	...	.....	....	.....	...	....	....
Cape Haytien	.....	...	.....	.....	...	.....	....	.....	...	....	....
Cardenas	.....	...	.....	.....	...	511	....	.....	...	....	....
Aux Cayes	.....	...	.....	.....	...	.....	....	.....	...	....	....
Cork or Falmouth	.....	...	.....	.....	...	.....	....	.....	...	....	....
Ponce	.....	...	.....	.....	...	.....	....	.....	...	....	....
Hayti	.....	...	.....	.....	...	.....	....	.....	...	....	....
Belfast	.....	...	.....	.....	...	.....	....	.....	...	....	....
Jacmel	.....	...	.....	.....	...	.....	....	.....	...	....	....
Martinique	.....	...	.....	.....	...	.....	....	.....	...	....	....
St. Pierre	.....	...	.....	.....	...	.....	....	.....	...	....	....
Bahamas	.....	...	.....	.....	...	.....	....	.....	...	....	....
Demerara	.....	...	.....	.....	...	.....	....	.....	...	....	....
Georgetown, Yucatan	.....	...	.....	.....	...	.....	....	.....	...	....	....
Surinam	.....	...	.....	.....	...	.....	....	.....	...	....	....
Cronstadt	.....	...	.....	.....	...	.....	....	.....	...	....	....
Lagnayra	.....	...	.....	.....	...	.....	....	.....	...	....	....
Porto Rico	.....	...	.....	.....	...	.....	....	.....	...	....	....
Matanzas	.....	...	.....	2, 650	...	.....	....	.....	...	....	....
Barcelona	.....	...	.....	.....	...	.....	....	.....	...	....	....
Port au Prince	.....	...	.....	.....	...	.....	....	8, 090	...	....	....
Havana	.....	...	.....	9, 463	...	.....	....	.....	...	....	....
Newcastle	.....	...	.....	.....	...	.....	....	.....	...	....	....
Bremen	.....	...	.....	.....	...	.....	....	.....	...	....	....
Total foreign, 1875	.....	...	.....	12, 113	....	511	....	8, 090	....	...	....
Total foreign, 1874	.....	...	.....	22, 898	....	150	....	.....	...	....	....
Total foreign, 1873	.....	...	.....	.....	...	.....	....	.....	...	....	....
Total foreign, 1872	.....	...	.....	.....	...	.....	....	.....	...	....	....

GRAND TOTALS—Continued.

Total coastwise and foreign, 1875	270	246	664	12, 113	65	1, 861	157	8, 090	63	224	24
Total coastwise and foreign, 1874	3, 570	399	8, 741	22, 898	175	3, 261	298	.....	....	....	....
Total coastwise and foreign, 1873	.....	....	.....	.....	....	.....	....	.....	....	....	....
Total coastwise and foreign, 1872	.....	....	.....	.....	....	.....	....	.....	....	....	....

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Statement of the principal articles of produce and manufacture exported from the port of Wilmington, N. C., for the year ending December 31, 1875, *&c.*—Continued.

COASTWISE—Continued.

Destination.	Cases of furs.	Barrels of fruit.	Barrels of liquor.	Rolls of leather.	Barrels of rosin-oil.	Hogsheads of molasses.	Bales of cane-fiber.	Packages of manufactured tobacco.	Bags of guano.	Barrels naphtha.	Cotton-ties.
New York	5	8	11	3	1	.....	20	40	396	12	....
Baltimore	7	105	22	36	155	.....	11	....	42	....	....
Philadelphia	....	.....	16	.....	.....	172	.....	....	....	....	....
Boston	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Bath	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Richmond	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Thomaston	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Bucksport	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Providence	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Burlington	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Total coastwise, 1875	12	186	49	39	156	172	31	40	438	12	....
Total coastwise, 1874	....	617	145	683	133	568	1,609	714	....	....	....
Total coastwise, 1873	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Total coastwise, 1872	....	.....	.....	.....	.....	.....	.....	....	....	....	....

FOREIGN—Continued.

Liverpool	....	.....	.....	.....	.....	.....	.....	....	....	....	....
London	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Amsterdam	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Rotterdam	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Bristol	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Granton	....	.....	.....	.....	.....	.....	.....	....	....	....	....
United Kingdom	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Antwerp	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Dordrecht	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Hamburg	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Greenock	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Stettin	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Glasgow	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Santiago de Cuba	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Hull	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Cape Haytien	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Cardenas	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Aux Cayes	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Cork or Falmouth	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Ponce	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Hayti	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Belfast	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Jacmel	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Martinique	....	.....	.....	.....	.....	.....	.....	....	....	....	....
St. Pierre	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Bahamas	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Demerara	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Georgetown, Yucatan	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Surinam	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Cronstadt	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Laguayra	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Porto Rico	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Matanzas	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Barcelona	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Port au Prince	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Havana	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Newcastle	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Bremen	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Total foreign, 1875	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Total foreign, 1874	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Total foreign, 1873	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Total foreign, 1872	....	.....	.....	.....	.....	.....	.....	....	....	....	....

GRAND TOTALS—Continued.

Total coastwise and foreign, 1875	12	186	49	39	156	172	31	40	438	12	....
Total coastwise and foreign, 1874	....	617	145	683	133	568	1,609	714	....	....	400
Total coastwise and foreign, 1873	....	.....	.....	.....	.....	.....	.....	....	....	....	....
Total coastwise and foreign, 1872	....	.....	.....	.....	.....	.....	.....	....	....	....	....

NOTE.—Below we give the exports from this city, via Wilmington and Weldon Railroad, which have not been noted in our columns, and which should be added to the totals "coastwise," as also to the "grand totals" for 1875: Bales of cotton, 3,969; Basks of spirits of turpentine, 183; barrels of rosin, 1,094; barrels of tar, 490; barrels of crude turpentine, 100; barrels of pitch, 50; bushels of pea-nuts, 4,954; bales of cotton goods, 461; bales of yarn, 58; packages of paper-stock, 101.

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Abstract of bids for building an apron at the New Inlet, Cape Fear River, North Carolina, opened August 6, 1875, at 12.5 p. m.

No.	Name.	Nature of work and price.	Remarks.
1	Bangs & Dolby.	For apron, first 930 feet from Federal Point, $23 per linear foot; next 1,550 feet, $18.28 per linear foot; next 1,715 feet, $94 per linear foot; first rise on section 1, $6.90 per linear foot; first rise on section 2, $4.95 per linear foot; first rise on section 3, $7.20 per linear foot. All additional rise pro rata. Will construct an apron and maintain it while constructing for $120,000. Will close New Inlet to low-water mark, and guarantee the same for one year, for $188,000.	Work guaranteed for one year. Drawings accompany bid.
2	M. A. Bryson ...	For apron, $20.90 per linear foot	Work not guaranteed.
		For apron, maintained to 4 feet above present bottom, $34 per linear foot.	Work guaranteed.
		Will close New Inlet for $205,000	Work not guaranteed.
3	Ross & Drane...	Will close New Inlet, for first plan, $346,000.....	Work not guaranteed.
		for second plan, $250,000	No guarantee to bid.
		for third plan, $250,000.....	Drawings accompany bid.
4	C. J. Degraw....	For apron, $90 per linear foot.....	Work not guaranteed.
		For each additional foot in height, $4.....	No Drawings.
		Will close New Inlet for $164,000	
5	F. H. Smith	For apron, $37 per linear foot.....	Work not guaranteed.
		First foot in height above 4 feet, $9 per linear foot.....	Drawings accompany bid.
		Second foot in height above 4 feet, $8 per linear foot	

Contract with Messrs. Bangs & Dolby.

REPORT OF MR. HENRY BACON, ASSISTANT ENGINEER.

IMPROVEMENT OF CAPE FEAR RIVER, N. C.,
UNITED STATES ENGINEER OFFICE,
Smithville, N. C., July 1, 1876.

MAJOR: I have the honor to submit the following report of operations in the improvement of Cape Fear River during the year ending June 30, 1876:

The work was under the immediate supervision of Capt. C. B. Phillips, Corps of Engineers, till January 18, 1876, when he was relieved for other duty, and its superintendence assigned to me.

The work done has embraced the initial step for closing the New Inlet, consisting of an apron of timber, brush, and stone, 4 feet in thickness and from 40 to 70 feet wide, extending entirely across the opening from the Federal Point jetty to Zeke's Island.

The deepening and widening the cut behind the Horseshoe Channel, near Snow's Marsh, to 12 feet deep at mean low-water, and 190 feet width.

The working of the suction-dredge Woodbury on the sand shoal near the upper end of the Horseshoe cut from July 1 to August 9, 1875, and on the Bald Head channel from Augnst 11, 1875, to February 1, 1876.

The removal of the confederate obstructions below Wilmington, near Brunswick River. The two lines removed aggregate about 1,500 feet length. After completion of the dredging at the Horseshoe cut, one machine, with tow-boat and scows, was employed 12 days (120 hours) dredging a channel across the shoal near Campbell's Island, and clearing the channel near the east jetty next below Brunswick River.

Surveys of the river begun last year have been continued, embracing the vicinity of Snow's Marsh and the new Horseshoe cut, and from Campbell's Island to some distance above Brunswick River. The maps from these surveys have been finished. A general map from Federal Point to Bald Head Channel is nearly finished. It will show the various changes of the shore lines, &c., which have occurred during the last 24 years, especially at Bald Head, Zeke's Island, and Federal Point.

Results of the work during the year: The apron at the new inlet, consisting of a layer of round timber 1 foot in thickness, closely rafted, and from 8 inches to 1 foot in thickness of brush on the same, and stone to make the whole thickness 4 feet, has been successfully laid, beginning at the end of Federal Point jetty and terminating at Zeke's Island, at the site of the Woodbury wharf, a distance of 4,352 feet.

The work has been done by Messrs. Bangs & Dolby under the contract dated September 6, 1875.

They have exhibited energy and skill in the prosecution of the work. The first mattress was placed October 7, 1875, and the last June 2, 1876. The stone filling was completed June 17.

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The mattresses, of which the foundation of the apron was composed, were mostly about 36 feet in width, with length corresponding to the breadth of the apron—the timber always lying transversely with the apron.

They were held by anchors, and sunk in position by being weighted with stone. After being sunk, the required amount of stone was placed on the work.

During the progress of the work there has been a tendency to scour the foundation just ahead of the apron as laid, so that the bottom of the foundation averages fully 3 feet below the original site. This is advantageous for permanent security. Scouring has occurred on both sides of the apron since placed to a distance of 100 to 150 feet or more, so that there is now an irregularly defined channel on each side, parallel to the apron, the deepest portions being usually from 30 to 60 feet from it and averaging 3 feet below the bottom.

The scouring is not adjacent to the aprons, excepting in a few instances. In many cases, sand has accumulated partly over the apron. There has been a remarkable accumulation of sand over the apron at its junction with Zeke's Island since it was laid. The sand has followed it and closed over it for a distance of 175 feet, thus extending the beach and island toward Federal Point.

On the whole, the result shows the superiority of the method of mattresses for the foundation of the dike. There is a good prospect of permanence of the foundation as now laid. As the work proceeds, it will probably be found advisable to increase the width of foundation in many places and perhaps to construct jetties of timber, brush, and stone, perpendicular to the dike, especially on the river-side.

The apron has been laid in three lines, or sections—the outer angles to the river-side. The first section is 920 feet in length and averages 53 feet in width. The second is 1,588 feet long and has an average width of 42½ feet; the third section, extending to Zeke's Island, is 1,844 feet long and 60 feet wide.

The condition of the old works along Zeke's Island, and connecting it with Smith's Island, is favorable.

There has been a very large accretion of sand nearly the whole length, and especially at the northerly portion of Zeke's Island.

The old works, near their juncture with Smith's Island, have apparently been more exposed by abrasion on the sea-side, where abrasion and accretion have alternatively occurred.

At the present time the work is safer than ever before, because the action of the sea has transferred a large amount of sand over the works to the bay-side, where there was before a considerable depth of water, and now a wide bank of sand is fast coming up to and above ordinary high-water.

The sand on the sea-side has covered the works safely from the ravages of the worms.

The swashes across the low, narrow part of Smith's Island, about 3 miles below the head, are entirely closed by the natural action of the sea, as should be expected, from their coming into very shoal water on the river-side at 3 miles distance from the channel, from a wide sandy beach on the sea-side.

The cut behind the Horseshoe channel is a great improvement. It is now in general use. The old channel is neglected. The new channel gives nearly or quite 2 feet greater depth of water, and has the very obvious advantage of straightness. The tendency to shoal at the upper end, where the ebb-tide sets across it toward the New Inlet, has decreased since the completion of the cut. It will not be wholly cured till the New Inlet is closed. The flood-tide sets directly through the channel from end to end.

The work has been done by Messrs. Curtis & Fobes, under the contract dated June 21, 1875. It was begun August 9, 1875, and completed May 13, 1876.

The materials dredged and removed from the cut during the year amount to 283,530 cubic yards, being mostly mud, with slight intermixture of sand, compact sand predominating for about ¼ mile at the upper end. The cut is about 1¼ miles in length. There are no other symptoms of deterioration.

There seems to be no material deterioration of the Bald Head channel since July 1, 1875.

No work has been done on it since February 1, 1876, when the suction-dredge ceased operations. There still remains a good channel of 11 or 11½ feet depth at mean low-water. It has moved slightly to the westward since February 1, as it was inclined to do before.

The depth is somewhat variable, as the bar is composed of shifting sand.

It is not probable that a reliable and permanent channel will be obtained till the full effect of the tidal current is secured by closing the New Inlet. The efficiency of the work already done at Smith's and Zeke's Islands and the New Inlet, in improving the natural channel, seems already demonstrated.

The suction-dredge Woodbury has been laid up since February 1. The boiler is old and in bad condition, and not worth repairing. The hull is badly worm-eaten, and, although she has been temporarily repaired with 1½-inch plank sheathing during the past year, it is not advisable to put in a new boiler without thorough repairs.

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The engines, pumps, and other machinery are in reasonably good order.

With thorough repairs and a large new boiler there would be no doubt of her efficiency. This method of dredging is no longer an experiment.

The beach at Bald Head has during the year gradually worn away from 100 to 150 feet width on the west side of the point.

There has been a large accretion of sand at the north point, which is extended northward about 200 feet, with the usual hook-shape. There has been no notable change at the Oak Island shore at the entrance.

The completion of the new Horseshoe Channel and the few days' work near Campbell's Island secure a present depth of 12 feet at mean low-water from Wilmington to Bald Head Channel, with a fair prospect of permanence, or small requirement for repairs. Closing the New Inlet will assure a permanent channel at the entrance, and the preservation of the new Horseshoe Channel.

PROBABLE OPERATIONS FOR THE COMING FISCAL YEAR.

It is assumed that the objective result desired is the closing of New Inlet.

True economy requires that the full amount of funds required for the completion of the work to low-water mark should be made available during the year.

If $100,000 or more be appropriated, I would recommend its expenditure mostly at New Inlet, in widening and raising the foundation already laid, and extending the dike gradually from Zeke's Island and Federal Point as fast as the accretions of sand will follow, and cover the work to the mean high-water mark, and deep scouring at the end of the completed work be thus avoided. From past experience, it is probable that scouring will occur, which will endanger the foundations unless they are thoroughly secured and widened. It will, therefore, be best to widen the foundations when needed, and gradually raise the dike to low-water mark, keeping careful watch and record of effects, so as to demonstrate the proper method of procedure.

On account of the great destructibility of wood and brush by worms, it is considered best to form the dike of stone (riprap) above the foundation mattresses, giving its sides the necessary slopes.

The present design is to make the slope on the sea-side 2 horizontal to 1 vertical, and 1 to 1 on the river-side, and the top width 16 feet at low-water. It is estimated that 62,000 cubic yards of stone will be required in widening and securing the foundation and raising the dike to low-water mark.

At least 16,000 cubic yards of stone will be required to raise the dike to 3 feet above high-water mark, the amount depending on the accretion of sand, which may be expected to give security to the work as its completion proceeds.

The prospect of accretion is much better on the sea-side than on the other side, which will be exposed to tidal currents not likely to leave deposits, excepting for a short distance at each end. Deposits may be encouraged by inexpensive perpendicular jetties, as before suggested. While the new inlet is being closed the operations of nature should be assisted in closing the channel at the mouth of the river.

I would recommend putting the suction-dredge Woodbury in thorough repair, and in operation on the Bald Head Channel.

Careful surveys and examinations of the New Inlet work and vicinity, and also of the new Horseshoe Channel and the bars at the mouth of the river, will be continued.

A series of simultaneous tidal observations at several points in the river, including Bald Head, Smithville, Snow's Marsh, Zeke's Island, Federal Point, Orton Creek, and Campbell Island, already begun, will be continued.

The results are not fully developed. One purpose is to make a record of present tidal movements to compare with tidal observations which may be taken after the New Inlet is closed.

A study of the few observations thus far made proves the disturbing action of the New Inlet.

There is no regularity as to the comparative time of high and low water at Bald Head and New Inlet. It varies at times nearly an hour each way, with no apparently adequate cause from force of winds. The time is most apt to be simultaneous.

The range of the tide is always less at the New Inlet than at the mouth at Bald Head. The average difference so far observed is about 9 inches. This is complicated with the variations in time, and the results are curious and beyond definite solution and computation.

The entrance-tides are much the greatest in bulk and ultimate force, but meet with great disturbance from the inlet.

The first flood of the inlet joins the main ebb and runs with great force around Zeke's Island toward the mouth, till met by the main flood, which forces it back gradually till toward the close of the main flood, when that in turn runs with great force *out* of the inlet with the first of the inlet ebb, while the main flood is still flowing past and above. In this case the currents near the central portion of the apron are north-

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ward and nearly parallel to it, sometimes crossing it near Zeke's Island, and recrossing toward Federal Point.

When the main current turns, this state of things is to some extent reversed, and the currents along the apron are southerly.

At nearly all stages of the tide there is a rush of water in or out of the inlet of various velocity, up to 6 miles or more per hour.

In short, the effect of the New Inlet is to retard and then empty a portion of the main flood, and thus prevent its filling the reservoir, and also in a similar manner to retard the main ebb and add to its volume at the critical time of meeting the main flood from the mouth.

These effects more than counterbalance the aid of the inward and outward flow at the inlet, in filling and emptying the reservoir.

From a study of the observations thus far made and recorded, and very frequent personal observation of the tidal motions at the inlet, and from past experience, observation, and study of tidal movement, I believe that after the New Inlet is closed, the range of the tides will be as great at Federal Point and for some distance above as at Bald Head. Thus the tidal reservoir will be greatly increased by the increase of range, and this, together with the large amount of water now flowing in and out at the inlet, will be added to the scouring power at the mouth.

I will annex a diagram exhibiting graphically the results of simultaneous observations made June 21, 1876. The effect of the New Inlet, which is directly opposite Snow's Marsh, is apparent from the diagrams. I will also annex a table of simultaneous observations, extending over portions of several days.

The zero of the several gauges is placed approximately at one level by a study of tidal movement.

The following are estimates for the expenditure of appropriations of $100,000, $150,000, and $200,000. It is hoped that the larger appropriation will be granted.

Estimate for expenditure of $100,000.

Repairs on suction-dredge Woodbury	$12,000
Operation of same 8 months	8,000
Widening foundations with mattresses at New Inlet	6,000
24,000 cubic yards stone for filling mattresses, $2.75	66,000
Surveys, superintendence, and contingencies	8,000
Total	100,000

Estimate for expenditure of $150,000.

Repairs of suction-dredge Woodbury	12,000
Operation of same 8 months	8,000
Widening foundations with mattresses at New Inlet	6,000
42,000 cubic yards stone filling mattresses $2.75	115,500
Surveys, superintendence, and contingencies	8,500
Total	150,000

Estimate for expenditure of $200,000.

Repairs of suction-dredge Woodbury	12,000
Operation of same 8 months	8,000
Widening foundations with mattresses at New Inlet	6,000
60,000 cubic yards stone filling mattresses, $2.75	165,000
Surveys, superintendence, and contingencies	9,000
Total	200,000

Respectfully submitted.

HENRY BACON,
Assistant.

Maj. WM. P. CRAIGHILL,
Corps of Engineers, U. S. A.

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Simultaneous tidal observations, June 20, 1876, Cape Fear River, North Carolina.

The zero of each of the gauges is approximately at the same level.

Time.	Bald Head.	Smithville.	Zeke's Island.	Federal Point.	Snow Marsh.	Orton Creek.
10.00 a. m	0.25	0.70	1.40	1.00	1.15	.....
15 a. m	0.15	0.40	.....	0.85	0.95	.....
30 a. m	0.00	0.30	1.15	0.70	0.80	.....
45 a. m	−0.20	0.10	0.90	0.45	0.60	.....
11.00 a. m	−0.30	0.00	0.80	0.40	0.50	.....
15 a. m	−0.35	−0.10	0.70	0.30	0.40	.....
30 a. m	−0.35	−0.15	0.60	0.20	0.25	1.00
45 a. m	−0.35	−0.20	0.40	0.12	0.20	0.80
12.00 m	−0.15	−0.15	0.30	0.12	0.15	0.70
15 p. m	+0.05	−0.00	0.20	0.30	0.12	0.60
30 p. m	0.30	+0.20	.....	0.45	0.10	0.50
45 p. m	0.65	0.50	.....	0.60	0.15	0.45
1.00 p. m	0.95	0.70	.....	0.75	0.30	0.40
15 p. m	1.30	.....	.....	0.95	0.55	0.40
30 p. m	1.65	1.40	.....	1.10	0.95	0.50
45 p. m	2.00	.....	0.60	1.40	1.30	0.60
2.00 p. m	2.50	2.20	1.00	1.70	1.60	0.80
15 p. m	2.90	.....	1.40	2.00	2.00	1.00
30 p. m	3.40	2.90	1.80	2.20	2.30	1.20
45 p. m	3.80	.....	2.40	.....	2.70	1.40
3.00 p. m	4.10	3.60	3.00	2.90	3.10	1.70
15 p. m	4.50	.....	3.40	3.10	3.45	2.10
30 p. m	4.80	4.30	3.80	3.50	3.80	2.50
45 p. m	5.20	.....	4.20	3.80	4.15	2.80
4.00 p. m	5.50	5.10	4.60	4.10	4.40	3.15
15 p. m	5.70	.....	.....	4.40	4.70	3.50
30 p. m	5.90	5.40	5.10	4.70	4.90	3.80
45 p. m	6.10	.....	5.30	4.90	5.05	4.10
5.00 p. m	6.20	5.90	5.60	5.10	5.30	4.40
15 p. m	6.25	6.00	5.70	5.40	5.50	4.70
30 p. m	6.30	6.10	.....	5.62	5.70	4.95
45 p. m	6.40	6.20	5.80	5.78	5.80	5.20
6.00 p. m	6.30	6.20	.....	5.86	5.90	5.40
15 p. m	6.10	6.10	.....	5.86	5.90	5.50
30 p. m	.....	5.95	.....	5.70	5.85	5.55
45 p. m	.....	.....	.....	5.66	.....	5.60
7.00 p. m	.....	.....	.....	5.56	.....	5.60
15 p. m	.....	.....	.....	.....	.....	5.50
30 p. m	.....	.....	.....	.....	.....	.....
45 p. m	.....	.....	.....	.....	.....	.....
8.00 p. m	.....	.....	.....	.....	.....	.....

REMARKS.—Weather clear; light southwest breeze all day.

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Simultaneous tidal observations, June 21, 1876, Cape Fear River, North Carolina.

The zeros of each gauge are approximately at the same level.

Time.	Bald Head.	Smithville.	Snow Marsh.	Federal Point.	Orton Creek.	Campbell's Island.
9.00 a. m	2.30	2.80	2.90	2.90	3.45	.....
15 a. m	2.05	2.50	2.60	2.50	3.25	.....
30 a. m	1.70	2.25	2.35	2.30	3.00	3.40
45 a. m	1.40	2.00	2.15	2.00	2.80	.....
10.00 a. m	1.15	1.70	1.90	1.90	2.60	3.00
15 a. m	0.90	1.40	1.70	1.70	2.35	.....
30 a. m	0.60	1.10	1.45	1.40	2.15	2.60
45 a. m	0.30	0.90	1.20	1.20	2.00	.....
11.00 a. m	0.10	0.60	1.00	+0.90	1.82	2.15
15 a. m	−0.10	0.35	0.80	0.60	1.62	.....
30 a. m	−0.30	0.15	0.60	0.40	1.50	1.85
45 a. m	−0.35	−0.10	0.45	0.30	1.35	.....
12.00 m	−0.40	−0.20	0.35	0.20	1.20	1.60
15 p. m	−0.45	−0.30	0.25	.....	1.10	.....
30 p. m	−0.45	−0.35	0.15	0.10	1.00	1.40
45 p. m	−0.35	−0.40	0.10	0.00	0.85	.....
1.00 p. m	−0.20	−0.30	0.10	0.00	0.75	1.25
15 p. m	−0.00	−0.10	0.10	0.20	0.65	.....
30 p. m	+0.30	+0.05	0.10	0.20	0.58	0.90
45 p. m	0.60	0.35	0.15	0.50	0.50	.....
2.00 p. m	1.00	0.60	0.40	0.60	0.45	0.70
15 p. m	1.35	1.00	0.90	0.90	0.40	0.65
30 p. m	1.90	1.40	1.30	1.20	0.45	0.65
45 p. m	2.30	1.90	1.65	1.50	0.60	0.70
3.00 p. m	2.70	2.30	2.00	1.80	0.80	0.70
15 p. m	3.20	2.70	2.35	2.30	1.10	.....
30 p. m	3.50	3.00	2.85	2.50	1.40	0.80
45 p. m	3.95	3.35	3.15	2.80	1.70	1.20
4.00 p. m	4.30	3.80	3.45	3.10	2.00	1.50
15 p. m	4.70	4.20	3.80	3.00	2.35	1.85
30 p. m	5.10	4.50	4.15	3.80	2.65	2.30
45 p. m	5.40	4.90	4.45	4.10	2.92	2.75
5.05 p. m	5.65	5.10	4.75	4.40	3.32	3.00
15 p. m	5.90	5.40	4.90	4.70	3.65	3.30
30 p. m	6.15	5.60	5.15	4.90	3.95	3.60
45 p. m	6.30	5.90	5.35	5.10	4.35	.....
6.00 p. m	6.40	6.00	5.65	5.50	.....	4.30
15 p. m	6.45	.....	5.65	5.60	.....	.....
30 p. m	6.50	6.35	5.70	5.80	.....	4.80
45 p. m	6.50	6.40	5.75	5.95	.....	5.25
7.00 p. m	.....	.....	.....	.....	.....	.....
15 p. m	6.30	6.40	.....	6.10	.....	5.60
30 p. m	6.20	6.35	.....	6.00	.....	5.70
45 p. m	.....	.....	.....	.....	.....	5.75
8.00 p. m	.....	.....	.....	.....	.....	5.70

REMARKS.—Weather clear, light northwest wind a. m.; moderate southwest wind all p. m.

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Simultaneous tidal observations, Cape Fear River, North Carolina, June 22, 1876.

Zero at the several stations approximately at one level.

Time.	Bald Head.	Smithville.	Snow Marsh.	Zeke's Island.	Federal Point.	Orton Creek.	Campbell's Island.
6. 45 a. m	4. 80	4. 70	.....	.....	.....	.....	.....
7. 00 a. m	4. 90	4. 80	.....	4. 40	4. 30	.....	3. 50
15 a. m	4. 80	4. 60	.....	4. 40	4. 50	.....	3. 75
30 a. m	4. 70	.....	.....	4. 40	4. 50	.....	4. 00
45 a. m	4. 65	4. 70	4. 45	4. 30	4. 40	.....	4. 20
8. 00 a. m	4. 55	4. 60	4. 40	4. 20	4. 30	.....	4. 35
15 a. m	4. 30	4. 45	4. 30	4. 10	4. 20	.....	4. 40
30 a. m	4. 10	4. 30	4. 20	3. 90	4. 10	.....	4. 45
45 a. m	3. 80	.....	4. 10	.....	3. 90	.....	4. 45
9. 00 a. m	3. 45	3. 75	3. 87	3. 70	3. 70	4. 10	4. 35
15 a. m	3. 15	.....	3. 72	.....	3. 40	3. 90	.....
30 a. m	2. 80	3. 10	3. 55	3. 20	3. 20	3. 70	4. 00
45 a. m	2. 50	.....	3. 37	3. 10	3. 00	3. 50	.....
10. 10 a. m	2. 20	2. 70	3. 15	2. 70	2. 70	3. 30	3. 70
15 a. m	1. 90	.....	2. 90	2. 30	2. 35	3. 10	.....
30 a. m	1. 50	2. 10	2. 70	.....	2. 10	2. 90	3. 35
45 a. m	1. 30	.....	2. 47	.....	2. 00	2. 70	.....
11. 00 a. m	1. 10	1. 60	2. 22	1. 80	1. 90	2. 50	2. 95
15 a. m	1. 80	.....	2. 00	1. 70	1. 50	2. 30	.....
30 a. m	0. 55	1. 10	1. 86	1. 50	1. 20	2. 10	2. 60
45 a. m	0. 30	.....	1. 60	1. 30	1. 00	1. 90	.....
12. 00 m	0. 10	0. 60	1. 35	1. 20	0. 70	1. 70	2. 20
15 p. m	—0. 05	.....	1. 15	1. 10	.....	1. 50	.....
30 p. m	—0. 20	0. 00	0. 97	0. 90	0. 30	1. 35	1. 90
45 p. m	—0. 35	.....	0. 80	0. 80	0. 12	1. 20	.....
1. 00 p. m	—0. 45	—0. 30	0. 60	0. 60	0. 12	1. 15	1. 60
15 p. m	—0. 50	.....	0. 47	0. 50	0. 10	1. 05	.....
30 p. m	—0. 55	—0. 50	0. 30	0. 40	—0. 10	0. 95	1. 30
45 p. m	—0. 45	.....	0. 22	0. 30	—0. 04	0. 80	.....
2. 00 p. m	—0. 20	—0. 40	0. 15	0. 10	+0. 10	0. 70	1. 10
15 p. m	+0. 30	—0. 20	0. 10	0. 00	0. 20	0. 60	.....
30 p. m	0. 70	+0. 10	0. 07	0. 00	0. 40	0. 50	0. 90
45 p. m	0. 90	0. 50	0. 05	0. 00	0. 60	0. 40	.....
3. 00 p. m	1. 10	1. 00	0. 05	0. 10	0. 70	0. 35	0. 75
15 p. m	1. 60	1. 40	0. 05	0. 40	1. 05	0. 35	.....
30 p. m	2. 00	1. 60	0. 10	0. 60	1. 30	0. 40	0. 60
45 p. m	2. 40	.....	0. 35	0. 80	1. 55	0. 60	0. 55
4. 00 p. m	2. 80	2. 30	0. 75	1. 10	1. 80	0. 75	0. 55
15 p. m	3. 20	.....	1. 15	1. 60	2. 10	1. 20	0. 70
30 p. m	3. 70	3. 10	1. 45	2. 20	2. 40	1. 60	0. 90
45 p. m	4. 10	.....	1. 75	2. 70	2. 70	1. 90	1. 10
5. 00 p. m	4. 40	*3. 60	2. 10	3. 30	3. 05	2. 20	1. 40

*High water 8 p. m., 6. 40.

REMARKS.—Weather clear; light northwest wind a. m. and light southwest p. m. The station at Snow's Marsh is at the northerly sluice. The station at Zeke's Island is at the old works, about 400 feet from Woodbury wharf.

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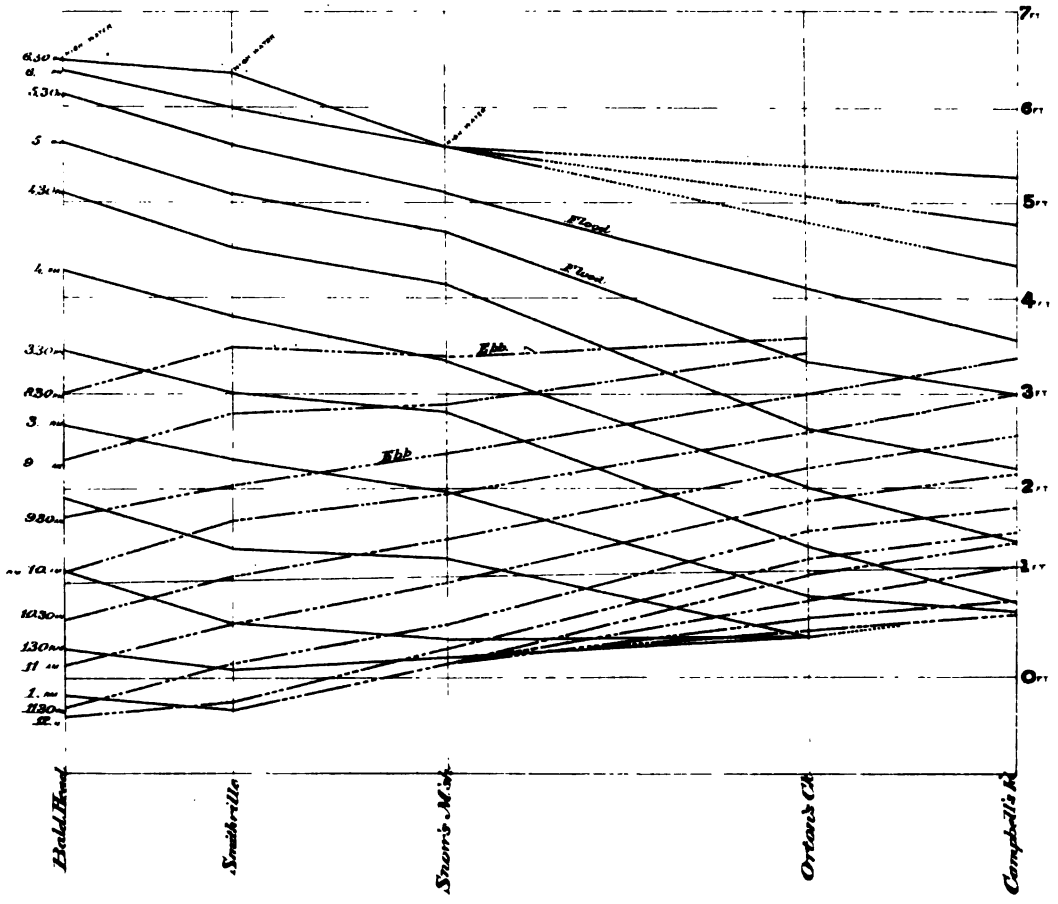

Diagram of

simultaneous Tidal observations

Cape Fear River N.C.

June 21st 1876

Vertical Scale 1 foot to 1 inch

Note.

Relative Horizontal Distances are approximately shown

No observations at Orton's Cr. after 5.30 p.m.

June 30th 1876

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Simultaneous tidal observations, June 23, 1876, Cape Fear River, North Carolina.

Time.	Bald Head.	Smithville.	Snow Marsh.	Zeke's Island.	Federal Point.	Orton Creek.
7. 45 a. m	4. 85	4. 70	.....	4. 30	4. 20	3. 35
8. 00 a. m	4. 90	4. 75	.....	4. 40	4. 30	3. 75
15 a. m	5. 00	4. 80	.....	4. 50	4. 40	4. 00
30 a. m	4. 90	4. 90	.....	4. 50	4. 50	4. 25
45 a. m	4. 85	4. 90	4. 52	4. 40	4. 50	4. 35
9. 00 a. m	4. 70	4. 70	4. 50	4. 30	4. 40	4. 45
15 a. m	4. 40	.....	4. 35	4. 20	4. 30	4. 45
30 a. m	4. 10	4. 35	4. 25	4. 10	4. 20	4. 45
45 a. m	3. 85	.....	4. 10	3. 90	4. 00	4. 30
10. 00 a. m	3. 55	3. 75	3. 92	3. 65	3. 80	4. 25
15 a. m	3. 20	.....	3. 72	3. 45	3. 45	3. 90
30 a. m	2. 90	3. 30	3 55	3. 25	3. 20	3. 40
45 a. m	2. 60	.....	3. 40	.....	3. 00	3. 60
11. 00 a. m	2. 25	2. 70	3. 20	2. 80	2. 80	3. 40
15 a. m	1. 90	.....	2. 92	.....	2. 40	3. 10
30 a. m	1. 60	2. 30	2. 70	.....	2. 10	2. 90
45 a. m	1. 35	.....	2. 50	.....	1. 95	2. 70
12. 00 m	1. 00	1. 75	2. 30	1. 95	1. 80	2. 50
15 p. m	0. 80	.....	2. 05	1. 70	.....	2. 30
30 p. m	0. 60	1. 15	1. 85	1. 60	1. 20	2. 10
45 p. m	0. 40	.....	1. 62	1. 40	1. 00	1. 90
1. 00 p. m	0. 15	0. 60	1. 40	1. 30	0. 70	1. 70
15 p. m	0. 00	.....	1. 20	1. 10	0. 50	1. 55
30 p. m	—0. 20	0. 05	1. 00	1. 00	0. 40	1. 40
45 p. m	—0. 30	—0. 05	0. 82	0. 80	0. 30	1. 20
2. 00 p. m	—0. 40	—0. 20	0. 65	0. 70	0. 20	1. 10
15 p. m	—0. 55	—0. 40	0. 50	0. 60	0. 15	1. 00
30 p. m	—0. 40	—0. 45	0. 37	0. 45	0. 01	0. 95
45 p. m	—0. 20	—0. 40	0. 25	0. 30	0. 00	0. 80
3. 00 p. m	—0. 10	—0. 20	0. 20	0. 20	0. 00	0. 70
15 p. m	+0. 10	—0. 00	0. 10	0. 10	0. 10	0. 60
30 p. m	0. 40	+0. 30	0. 07	0. 05	0. 40	0. 50
45 p. m	0. 75	.....	0. 05	0. 10	0. 55	0. 45
4. 00 p. m	1. 10	0. 80	0. 07	0. 20	0. 90	0. 40
15 p. m	1. 50	.....	0. 15	0. 40	1. 10	0. 40
30 p. m	2. 00	1. 50	0. 40	0. 60	1. 30	0. 50
45 p. m	2. 40	.....	0. 80	0. 90	1. 55	0. 75
5. 00 p. m	2. 80	2. 20	1. 15	1. 15	1. 90	0. 90
15 p. m	3. 20	.....	1. 47	1. 80	2. 30	1. 20
30 p. m	3. 70	3. 15	1. 80	2. 30	2. 60	1. 50
45 p. m	4. 10	.....	2. 10	2. 90	2. 90	1. 85
6. 00 p. m	4. 65	4. 30	2. 45	2. 30	3. 25	2. 25

REMARKS.—Clear weather; calm moderate southwest breeze p. m. Observations are recorded in feet and hundredths above and below the zero of the several gauges.

HISTORICAL SKETCH OF THE IMPROVEMENT OF THE CAPE FEAR RIVER BELOW THE CITY OF WILMINGTON, N. C.

BALTIMORE, MD., *July* 1, 1876.

SIR: The mouth of the Cape Fear River at one time formed one of the finest entrances on the South Atlantic Coast. As a harbor of refuge, it was and still is, for a certain class of vessels, of great importance. Located, as it is, on a portion of the coast which is subject to severe gales, it is the only harbor accessible to deep-draught vessels between the ports of Beaufort, N. C., and Charleston, S. C.

The Cape Fear River and its principal tributaries flow through a section of country abounding in iron, copper, and other metals, and large deposits of bituminous coal of superior quality are found. The immense forests of pine furnish an almost inexhaustible quantity of excellent timber and naval stores; the latter form the principal articles of export, and are always in demand from all quarters of the world.

The advantages of the Cape Fear as a site for a proposed naval coaling-station have often been mentioned.

The attention of settlers was drawn to this region at an early day. The first settlement was made about the year 1660, by a band of emigrants from New England. They settled at a point on the western bank of the river, about 9 miles below the site of the city of Wilmington. The country did not realize their expectations, and, after suffering great distress and being harassed by Indians, they abandoned the settlement and returned to New England. The next attempt at a settlement on the Cape Fear also proved a failure, although it was not as short-lived as the first colony, and at one

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time, it is said, numbered 800 people. This second band of emigrants came from the Barbadoes, and settled in 1665 at the point formerly occupied by the New Englanders. This colony gradually dwindled away, many of the colonists going farther south and settling portions of what is now South Carolina, until about the year 1690, when the settlement was entirely abandoned.

The date of the third attempt at a settlement, and the one which finally proved permanent, is not exactly known. It must have been during the very early part of the eighteenth century, if not before the close of the seventeenth, for we read in detail of the Indian wars on the Cape Fear River during the years 1711–'13.

The old town of Brunswick, on the west side of the river, about 15 miles below the site of the city of Wilmington, was laid out in the year 1725. About five years later a settlement sprang up at the site of the city of Wilmington, and was at first called New Liverpool. In 1735 its name was changed to "Newton;" and in 1739 it received the name which it bears to-day.

Wilmington soon became a rival of the older town of Brunswick, and gaining supremacy, finally entirely absorbed the latter.

The relics of Brunswick are still to be seen in the shape of a desolate grave-yard, and the brick walls of an old church.

While these details have no direct bearing upon the subject of the improvement of the river, yet they go to show us that we need not expect to find on record any very definite information about the condition of the river, its depth, &c., during these early days.

A half century had been spent in fruitless attempts to make a permanent settlement of the country; and afterward, when a colony was finally established, the attention of the colonists was probably too much taken up by Indian wars and other difficulties to allow them to go into particulars about a matter of which they probably cared little, so long as they had water enough and to spare for their primitive necessities.

There seems to be no doubt, however, that during these early days vessels drawing as much as 19 or 20 feet of water could readily pass into the Cape Fear River at high-water.

From the earliest information (in any way reliable) to be had on the subject, there was a depth of 14 feet of water at low-tide upon what is now known as the Eastern or Bald Head Channel. This is from the map of a survey made by Edward Mosely, in the year 1733.

The same map indicates a depth of 9 feet in the present Western or Oak Island Channel. Five years later Weimble's chart of North Carolina was published. But few soundings appear on this map; but the printed sailing directions give 3½ fathoms on the main bar at high-water. This would call for 16½ feet at low-water. Nine feet is shown on the rip or inner bar of the Western Channel, presumably at low-water. Up to this time New Inlet had no existence. The next map to be found is one by Captain Collet, colonial governor of Fort Johnston. The date on the map is indistinct, but is believed to be 1774. It states that it was made from actual surveys, and upon it appears the New Inlet. No soundings are given either at the inlet or at the old mouth of the river. The inlet had, however, been in existence some years prior to the publication of this map. The traditions of the country give the year 1762 as the date of the opening of the inlet. An article published in the London Magazine, December, 1761, gives an account of a violent equinoctial storm, which commenced September 20, 1761, and lasted four days, during which the sea made a breach 18 feet deep at high-water, and nearly half a mile wide, through the outer beach, at a place called the "haul-over." This was no doubt at the present site of the inlet. The locality probably derived its name from the practice of the pilots and fishermen of hauling their boats over the narrow shingle-beach separating the river from the ocean. This practice, no doubt, denuded the beach of its scant vegetation, and perhaps, under the action of winds, even lowered the level of the beach at this point. Tradition says the famous storm, referred to above was a "dry blow," and it is easy to imagine that under such circumstances a depression might soon be made in the dry sand sufficient to permit of the trickling through of water from the river to the sea. At the epoch of high water on the river-side of the beach, the tide on the outside had been falling for over an hour, and, with this difference of level, the trickling stream would soon deepen and widen, until a serious breach had been established.

It is not probable that the action of the waves upon the outer beach had anything to do with making the opening; but, on the contrary, their action would tend rather to restore and maintain the beach. It is proper to state in this connection that the tide at the New Inlet is some 25 minutes earlier than at the old mouth of the river, it being delayed at the latter point by the Frying Pan Shoals, extending out some 20 miles to sea from Cape Fear. This state of affairs explains why (before the breaking out of the inlet) so great a difference of level existed between the water inside and the water outside the beach.

Since the breaking out of the inlet, an equally anomalous result follows from the same cause, in this, that the water commences running out of the inlet long before the

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ood ceases to come in at the old mouth. Consequently, during the *early* stage of *ebb-* *le* at the *inlet*, the water running *up* the river, passes out at the inlet for a certain me, or until the influence of the later ebb at the old mouth can be felt above. This ibject will be touched upon again in connection with remarks upon the formation of e "Horseshoe Shoal;" it is sufficient for our purpose at present to merely state that is condition of the tides adds greatly to the quantity of water passing out of the let, and to the resulting scour; and is no doubt the principal reason why the New let has proved more stable and unshifting in its character than most of the other merous inlets on the North Carolina coast. In the statement quoted above from the ndon Magazine, (December, 1761,) which says that the breach at the "haulover" as 18 feet in depth at high-water, there seems certainly to be an exaggeration. At l events, there seems to be good authority for saying that for some years the inlet as fordable. A road passed over the site of the inlet, communicating with the set- ement at or near Bald Head, and there are reliable people now living who have ard "old folks" say that they had crossed the inlet in buggies. The next oldest aps of the Cape Fear River were published in 1794. Of these there are 2: 1 by apt. H. Holland, the other by Henry Mouzen "and others." At this time the New let had been in existence over 30 years, and its effects upon the main bar were very anifest. Upon both these maps are printed the words "10 feet bar at low-water." t the rip (Oak Island channel) 6 feet are given at low-water. The New Inlet ap- ears, but no soundings are given. Next we have a "Sketch of Cape Fear River and trance, as surveyed in 1797 by Joshua Potts." This map shows soundings at low- ater as follows: Main bar, 15 feet; rip of western channel, 3 feet; New Inlet Bar, 6 et. Upon this map appears for the first time printed sailing-directions for entering he New Inlet. This depth on the inlet bar is nearly as much (within 18 inches) as is o be found at the present day. If the maps of 1794 and 1797 are to be relied upon, we ee that during the 3 years the main bar deepened 5 feet, and, as if to partially compen- ate for this, the rip of the Oak Island channel shoaled 3 feet.

In 1820, according to Major Kearney, Topographical Engineers, U. S. A., there was at main bar only 9 feet of water, at rip 6 feet, at New Inlet no soundings given. Three ears later, Mr. Hamilton Fulton, State engineer of North Carolina, reports that "a probable change has taken place on the main bar," and that "in the course of 18 months the depth of water has increased 2 feet," also that "no alteration has taken place in the depth of water at New Inlet."

In 1839, Lieutenant-Commander Glynn, U. S. N., made a survey of the entrances to the Cape Fear River and gives the following depths: Eastern bar, 8 feet; rip of western channel, 9 feet; New Inlet, 10 feet.

In 1851, Lieutenant Maffit, U. S. N., gives the following depths: Eastern bar, 8 feet; rip of western channel, 7 feet; New Inlet, 8 feet.

Although the map of 1851 shows the same depth on the main bar as is shown on the map of 1839, yet a comparison of the 2 maps shows that serious changes took place during this interval of 12 years between the publication of the 2 maps in question—the eastern bar had more than doubled its width, and, in addition, had become more tortuous. We also find that Bald Head Point had worn away considerably.

Previous to the year 1853, no work for the improvement of the entrances to the Cape Fear River had been attempted. A large amount had been expended upon the improvement of the upper river near Campbell's Island, and between that point and the city of Wilmington. This work was commenced by the State government in 1823, and was continued until 1829, when it was taken up by the United States Government and continued until the year 1838. This work will be referred to again in connection with more recent operations by the General Government in the same vicinity.

In 1853 a commission, consisting of Prof. A. D. Bache, Superintendent United States Coast Survey; Lieut. C. A. Davis, United States Navy; Capt. D. P. Woodbury, United States Engineers; and Maj. I. I. Stephens, United States Engineers, was appointed to report upon the improvement of the Cape Fear River at and below Wilmington. This report was submitted on March 30, 1853. The conclusions to which the commission arrived, and the recommendations made by them, as well as the report thereon of the Board of River and Harbor Improvements, will be found in a paper prepared by the late Lieut. Col. J. G. Foster, Corps of Engineers, and printed in the report of the Chief of Engineers for the year 1873, pages 804–815. In brief, it was proposed to protect Bald Head Point from further abrasion by the construction of jetties to close 2 small openings through the narrow beach of Smith's Island, near and below the New Inlet, and to construct a jetty at the northern extremity of Zeke's Island, the latter to prevent the New Inlet from extending farther south. These plans having met with the approval of the Chief Engineer of the Army and the Secretary of War, Capt. D. P. Woodbury, Corps of Engineers, was charged with the execution of the work. During the following summer (1853) Captain Woodbury commenced operations at Bald Head Point. The main work consisted of 2 stone jetties, the one 300 feet in length and perpendicular to the outer beach; the other 100 feet in length, running also from the outer shore, but starting from nearer the point. A pile wharf was also constructed;

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grillages of palmetto, loaded with stone, were sunk between the piles. The beach on one side of the railroad from the wharf to the jetties was also strengthened by means of a row of large stones. A line of brush fence, about 500 yards long, was also built parallel to the outer shores. The next season (spring of 1854) Captain Woodbury commenced the construction of a line of railroad running from the northern extremity of Zeke's Island to connect with the proposed dikes for closing the small inlets through Smith's Island beach. One branch of the road also ran along the New Inlet shore of Zeke's Island to supply stone for the construction of the proposed jetties along that shore; at the northern terminus of this railroad a wharf was built for the landing of stone.

During the summer of 1854, the more northern of the small inlets was partially closed; but a storm in September of that year enlarged it to about double its previous width, besides increasing its depth considerably. Later in the fall the sand between the 2 inlets was washed away, and the 2 became 1 inlet 2,300 feet in width, and in places, it is said, 12 feet in depth. During the next season, however, (1855,) the railroad was extended, and a grillage loaded with stone was sunk entirely across this enlarged opening. The opening was thus contracted to about 700 feet in width at low-water. The short jetties from the shore of Zeke's Island were built, and the jetties at Bald Head were extended. These Bald Head jetties had been commenced (as stated above) 2 years previously. As they were extended, the sand accumulated around them with rapidity, and it was also observed that as they were extended, the water on the rip of the western, or Oak Island channel, commenced to improve. In 1855 the water on the rip had deepened to 9 feet at low-water, which was more by from 1 to 2 feet than was to be found on the eastern bar, and the latter was abandoned except by very light-draught vessels. In 1856, the Bald Head jetties were still further extended by Lieutenant Whiting, Corps of Engineers, who was then in charge, since which date nothing more has been done at that point. It is understood, however, that the additions to the jetties in 1855 and 1856 only carried them to the length proposed by the board of 1853.

The work at the small inlet through Smith's Island, which, as stated above, was in the summer of 1855 reduced to a width of 700 feet at low-water, was in November of that year almost entirely destroyed by a storm. The work was replaced by Lieutenant Whiting during the following year, 1856; sheet-piling, brush, sand-bags, &c., being used in the construction of the work. In October the opening is reported as entirely closed. During the same year the jetties at Zeke's Island were strengthened by the use of additional stone.

On September 1, 1857, Col. William Turnbull, Topographical Engineers, reports that the beach has made entirely across the inlet closed by Lieutenant Whiting; but later he reports that the gale of September 11–13, 1857, has almost entirely destroyed the work; that the breach is again open to a width of over 2,400 feet, and that 2 other breaches have opened farther south.

In 1858 a commission, consisting of Prof. A. D. Bache, Superintendent United States Coast Survey, Hon. I. I. Stephens, M. C., Lieut. J. N. Maffit, U. S. N., Capt. A. A. Humphreys, Topographical Engineers, Capt. William B. Franklin, Topographical Engineers, and Lieut. W. H. C. Whiting, Corps of Engineers, was appointed "to examine into the condition of the entrances of the Cape Fear River," &c. Their report was submitted on December 30, 1858, and the substance of it will be found in the paper of the late Colonel Foster, before referred to. In brief, they conclude that the jetties at Bald Head have been successful, and that "the works on Zeke's Island fulfilled their object until the occurrence of the extraordinary storm of September, 1857." They also believed that the deepening of Oak Island channel was due to the work. They therefore recommended that the old works and jetties at Zeke's Island be restored, that the narrow beach of Smith's Island be protected by jetties perpendicular to the shore; and finally, if in the course of 3 years the main entrance should not increase in depth so as to admit vessels of as great draught as can pass up the river, that the closing of the New Inlet be undertaken. The commission requested that the Coast Survey might make a new survey of the main entrance. The result of the survey shows the following depths: Eastern channel, 8 feet; rip of western channel, 7 feet; New Inlet, 8 feet. On the chart, 2 inlets are shown south of Zeke's Island.

From this time on through the years of the late civil war, and until 5 years after its close, nothing more was done for the improvement of the Cape Fear River. During this interval, the bars at the main entrance continued to deteriorate. The eastern channel shoaled up to less than 7 feet, and the rip of the western channel remained less than 8 feet, although this channel was used exclusively. The small inlets through Smith's Island gradually enlarged, until they united in one common passage over 1,400 yards in width, or equal to that of the New Inlet itself. At low-water over this space there were to be seen a few sand shoals, which marked the sites of the old dividing ridges between the small inlets; and a few piles of rock could be seen, which were portions of the ruins of the old works and the old jetties which were once on the shores of Zeke's Island. The depth over this space at low-water varied from 0 to over

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10 feet. At the New Inlet, no great changes had taken place, the same depth of water remained on the bar, about 7½ feet, but the bar had moved considerably to the north, and it is supposed that this change was due to the influence of the increased volume of water coming from the south through the new breaks.

Zeke's Island had worn almost entirely away, and at extreme high-water appeared as a small sand-spit, just showing above the surface of the water.

It was while this state of affairs existed that Congress, in 1870, appropriated $100,000 for the "improving the Cape Fear River below Wilmington, N. C.," and Col. J. H. Simpson, Corps of Engineers, was charged with the execution of the work. Colonel Simpson, after an examination of the river, coincided with the opinion of the Board of 1868 as to the necessity of closing the spaces between Smith's and Zeke's Islands as the first and most important step of any further plan of improvement, and accordingly recommended that a line of crib-work, with superstructure brought to above high-water mark, be constructed across the space, beginning at Smith's Island and following such a line as would take most advantage of the remnants of the old works. This recommendation having been approved, work was commenced in 1870. Colonel Simpson remained in charge of the work but a short time, as on November 7, 1870, he was relieved by Maj. W. P. Craighill, Corps of Engineers, who has remained in charge of the work up to the present date.

During the fiscal year ending June 30, 1871, the crib-work, with superstructure completed, was extended a distance of 607 feet from Zeke's Island. This distance extended over the deepest portion of the space between the islands, and much difficulty was experienced in sinking some of the cribs, owing to the great velocity of the water, which increased as the line of cribs advanced.

The increased velocity of the water added so much to the scour that several of the cribs put in position this year were over 30 feet in depth.

During the latter part of this fiscal year (May, 1871) a Coast Survey party, in charge of Mr. Charles Junkin, made a survey of the old entrance to the river, and reported 7 feet on the bar of the eastern channel and 9½ feet on the rip of the western channel. This increase of depth on the rip was very remarkable; the increase being 2 feet since the work commenced, an interval of only 8 months. There seems to be no doubt but that this increase was due, partly at least, to the influence of the work already constructed.

During the fiscal year ending June 30, 1872, the construction of the breakwater was continued, an appropriation of $75,000 having been made in March, 1871. Thirteen hundred and eight linear feet of crib-work and completed superstructure were built during the year, making the total length of work 1,915 feet, or nearly one-half way across to Zeke's Island. All the deepest water had now been crossed, and in no place in advance of the work were over 7 feet of water to be found at low-tide. During the summer of 1871 a considerable abrasion was noticed at Bald Head Point, and in September of that year the shore ends of the jetties at that point were completely turned. This indicated that the volume of water passing out the old mouth had increased materially. A Coast Survey party, in charge of Mr. W. I. Vinal, was, under the direction of Major Craighill, engaged during the following winter and spring (1872) in making a survey of the main entrances to the river. This survey demonstrated the fact that a new and well-defined channel was forming at the eastern entrance, almost in the exact position formerly occupied by the old Bald Head channel.

The soundings indicated a depth of 9 feet at low-water, entirely across the bar, although there were several lumps found on which there were but 7 and 8 feet. At this time the jetties at Bald Head were separated from the shore by a breach 140 yards in width.

In December, 1871, Major Craighill requested that a Board of Engineers might be ordered to consider the various matters connected with the Cape Fear improvement. Accordingly, a Board was appointed, consisting of Lieut. Cols. Z. B. Tower, H. G. Wright, and J. G. Foster, and Majs. Q. A. Gillmore and W. P. Craighill, all of the Corps of Engineers.

The Board met at Wilmington, N. C., on January 24, 1872, and, after an examination of the river and works, made a preliminary report. The Board met again at New York City on December 6, 1872.

A full report of the proceedings of the Board is printed in the Annual Report of the Chief of Engineers for the year 1873, pages 797–803.

As nothing in the recommendation of this Board affected the continuation of the breakwater between Smith's and Zeke's Islands, we will go on with the operations for the fiscal year ending June 30, 1873. At the beginning of this year 1,915 linear feet of the work had been completed, and the space remaining to Zeke's Island was 2,488 feet. This entire space was cribbed, and the superstructure completed during the year, the last spike having been driven on the 30th of June. Total length of the entire work, 4,493 feet.

From the very commencement of the work at Smith's Island, a sand-spit somewhat above high-water mark followed along on the outer or sea side of the work, its extreme point, however, always keeping a little behind the advanced superstructure. Nor

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would this sand-spit join the work at any point, but followed along in a direction generally parallel to the work, and at a distance from it varying from 40 to 200 feet

This left a water-way along the work, in which the tide rose and fell with the tide of the inlet. It was partly supplied, however, by water which at certain points (particularly at the deep holes) leaked through the crib-work. To avert any disaster which might result from this, and to encourage the accumulation of sand on the outer side to protect the timber from worms, several useless and worn-out flats were sunk at the narrow points of this water-way, connecting the work with the sand-spit. About 30,000 sand-bags were also filled and deposited along both sides of the work. The result was that several ponds were formed along the outer side, which began rapidly to fill up with sand.

As the superstructure approached completion, the accumulation of sand became very rapid, not only in the ponds, but along the entire work. Numerous shoals, far beyond this sand-spit, also began to show themselves at low-water.

During the first year of the work an attempt was made to strengthen the narrow beach of Smith's Island, to the south of the works, by the construction of catch-sand fences filled in with brush, and by the planting and sowing of the native beach-grass. These efforts were continued from time to time while the work was in course of construction, and with tolerable success, many of the low places having been elevated several feet above their original level.

At the Bald Head Channel, at the old mouth of the river, there was a marked change and a manifest improvement during this year. In May of this year (1873) a Coast-Survey party made a resurvey of the channel, and found fully 9 feet of water entirely through the channel, the lumps which were found the year before having disappeared. Between the 9 foot curves at this time there was a distance of 100 yards at the narrowest part.

Before reviewing the operations of the fiscal year ending June 30, 1874, we will refer to two of the recommendations of the Board of 1872, at their final meeting in December, 1872, as they touch upon the year's work in question. The two recommendations referred to are as follows:

"2. That dredging be undertaken in the Bald Head Channel (which seems to be opening) as soon as funds are available for that purpose, the mode and amount of dredging to be left to the discretion of the superintending engineer;" and,

"5. That the closing of New Inlet is very desirable, and should be attempted as soon as funds are available; that, with this object, a jetty should be commenced from Federal Point, and follow the shoals in a general southwesterly direction, as indicated on the latest map." * * *

In accordance with the above recommendations, a project was submitted to and approved by the Chief of Engineers, which contemplated the construction of a jetty at Federal Point, on the northern side of the New Inlet. It had been proposed to attempt some form of structure more simple than crib-work, as, for instance, pile-work filled with brush; but, in view of the success of the cribs at the old work, and in order to secure a good landing and to make a shelter for the flats and boats in use on the work, it was decided to construct the first 500 feet of the jetty of cribs similar to those at the old work.

In anticipation of this work, quarters had been built for the laborers, and a considerable quantity of timber stored at Federal Point, and work upon the jetty commenced during the very early part of July, (1873.) As the work progressed, a very serious deepening occurred in advance of the line of cribs. By the time 200 linear feet had been placed in position, cribs 12 feet in depth were required where originally there were only 6 feet of water; and when, in the November following, the last crib (completing the 500 feet) was placed in position, it was sunk in 19 feet of water; the original depth having been only 6 feet. Many of the cribs settled rapidly after having been put in position, and it was only by great exertions that the cribs could be built upon fast enough to keep them above low-water mark.

It was now determined to go no further at present with the jetty, either in its present or any modified form of structure, but to wait until the effects of the work should develop themselves. Meanwhile a project for continuing the work at other points was submitted to the Chief of Engineers, and by him approved, (December 10.) The project contemplated an attempt to remove the so-called "Logs," or obstructions above Campbell's or "Big Island," about 11 miles above the New Inlet, and 8 miles below the city of Wilmington. Reference has already been made to certain work done by the State government of North Carolina between the years 1823 and 1829. Much of this work was at the site of the shoal known as the "Logs," or in its immediate vicinity. The main channel formerly passed to the west of Campbell's Island. It seems to have been the idea of the State engineer (Mr. Fulton) to shut off this channel and cause all the water to pass to the east of the island. This he succeeded in doing by means of a dike from the island to the western shore of the river, assisted by a jetty or deflector located a short distance above. The result of this movement was to cause the river to seek a new channel directly across the "Logs." It never succeeded in finding

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or making over 9 feet of water at low-tide. Capt. Hartman Bache, Topographical Engineers, who was in charge of a survey of the Cape Fear River, (directed by Congress in May, 1826,) in a report dated November, 1827, disapproves of the plan of shutting off the channel to the westward of Campbell's Island, but states that as the dike constructed has already caused the formation of shoals above and below it, he deems it inexpedient to re-open the channel.

The commission of 1853 also state in their report that "the closing of the channel west of Campbell's Island by the State of North Carolina, in accordance with the plan of Mr. Fulton, was a mistake, as it was the best channel at that time, and as good as the present channel has been made by the expenditure of over $200,000."

If, in 1827, the channel to the west of the island had so shoaled as to make it inexpedient to re-open it, it is easy to imagine its condition in 1874, or 47 years later. For a distance of about 3 miles the site of the old channel was occupied by an immense flat, with here and there a small pocket to indicate its old locality.

There seemed then to be but one practicable way of improving this portion of the river, and that by simply cutting a channel-way through these obstructions. Deep water (from 15 to 18 feet) was to be found for miles both above and below the shoal; and there was every indication that, by removing the obstructions, not only would the channel maintain itself but deepen under the action of the river-currents. A large dredge-boat was chartered, fitted out with grappling apparatus, and, proceeding to the Cape Fear, was engaged at the "Logs" from the 25th of March to the 11th of April, 1874. The state of funds available for the work prevented a longer charter of the dredge; but the time was ample to demonstrate the feasibility of cutting a channel across these obstructions to any desired width at a very moderate cost. The result was one cut entirely across the upper portion of the shoal, or what was known as the "Logs," (a shoal existed immediately below, and will be referred to hereafter,) and, in addition, a second cut about one-third of the way across, over the worst portion. The locality, it seems beyond doubt, must have been at some time the site of a cypress-swamp. Many cypress-stumps were removed, ranging in diameter from 4 to 7 feet, together with thousands of smaller stumps, cypress knees and roots. But few logs were found, and those evidently had floated there from some other locality. The stumps that were found projecting above the bed of the river were as sound as the day they grew, and were battered by the keels of vessels which had been passing over them for the last 50 years. Perhaps the most singular feature about these stumps was the evidence that they had been eaten off by the *teredo*, which, as is well known, works only in the salt water.. This, in connection with the fact that the water above Campbell's Island has been perfectly fresh since the early settlement of America, goes to show the great age of these stumps. To go back one step further, and remark that the cypress can grow only in or in the vicinity of fresh water, and we only add one more period o unknown duration to the age of these remarkable stumps.

The project approved December 10, 1873, also contemplated the fitting out of an ordinary steamer as a suction-dredge to work at the mouth of the river, at the eastern or Bald Head entrance.

A propeller of 145 tons burden was purchased for this purpose. Her dredging apparatus consisted of a 9-inch centrifugal pump, driven by a double oscillating engine, (10-inch cylinders,) the steam for the same being supplied by the boiler of the steamer. The suction-dredge was fitted out and prepared for work during the early part of April, (1874.) Before she had made a fair trial of her capabilities, she was called off to assist in towing the grapple-dredge to the North, and did not return to her proper station until after the close of the fiscal year.

While the Federal Point jetty was in progress, and during the remainder of the fiscal year, manifest changes were taking place below. At the old works, between Smith's and Zeke's Islands, the sand continued to accumulate in immense quantities, until at the close of the year the islands were nearly united by an almost continuous beach. The shoals beyond this beach continued to grow higher, and Zeke's Island began to resume its former shore-line as indicated by old maps. During this year Zeke's Island commenced growing toward the north and west, thus somewhat contracting the width of the New Inlet, though abrasion rather than accretion had been looked for at this point as the result of the Federal Point work. Going further down the river, we find a threatened break at a point of the Smith's Island beach about 3 miles below the old works, known as the "weak point" of the beach. Attempts have been made to strengthen the narrow beach at this point, by means of catch-sand fences; but, in spite of this precaution, two swashes or small inlets occurred here during this year, (1874,) through which quite a volume of water passed at and near high-tide. The distance of these points from the channel of the river, (over 3 miles,) and the character of the flats between, being full of oyster-rocks, prevented any great apprehension being felt concerning them. No attempts were made to close these swashes, although they were carefully watched for any indications of serious danger. These need not be referred to again, as the swashes gradually filled up under the action of the sea, and the beach became apparently stronger than before the breaks occurred.

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The gradual wearing away of Bald Head beach continued, but the loosened sand brought in by the flood-tides built itself up in the form of a hook on the inner side of the beach, and the distance across to Oak Island, on the other side of the mouth, became no greater.

A Coast-Survey party made a resurvey of Bald Head Channel during the months of May and June. Ten feet of water was found entirely over the bar, a clear gain of 1 foot during the year. The channel was buoyed out during the year, and an occasional vessel passed safely through. The depth of water on the rip of the western channel remained at about 9 feet.

The most interesting feature in the operations for the fiscal year ending June 30, 1875, was the cutting of a channel behind, or to the west of, the "Horseshoe" Shoal, located on the western side of the river, and opposite and below the New Inlet.

The older maps, executed before the breaking out of the New Inlet, are so meager in details that it is impossible to tell by them whether the channel formerly passed to the east or the west of the present site of the shoal. The concave form of the western shore at this point, the bluffs along the bank, and the existence of deep pockets near this shore, lead the observer to conclude beyond a doubt that at some time the main channel was here. The inference is that the channel was drawn toward the eastward, due to the influence of the inlet-current, that the old channel became filled up, and that the water, seeking a more eastern route, cut out the present shallow and tortuous channel around the "Shoe." Less than 9 feet of water can be carried around the "Horseshoe" at low-tide. It is very easy to perceive how this whole shoal might have been formed under the influence of the tides at the inlet. The flood-tide coming in at the inlet runs *down* the river for a full hour before it meets the flood-tide coming up from the old mouth. The point at which these distinct tides meet varies each day with the prevailing wind, state of the river as to freshets, &c., but is always located within the limits occupied by this shoal. The same may be said of the point of separation of the two ebb-tides, one starting *up* river to go out at the inlet, the other going *down* to pass out at the old mouth.

This constant meeting and separating of contrary currents is sufficient to account for the deposition of this material.

The dredging behind the Horseshoe, although acknowledged to be to a certain extent experimental, had in its favor these advantages: the new channel would naturally assist and be assisted by any future work for the construction of New Inlet; the water drawn away from the inlet would necessarily have to pass out at the old mouth; and, if the channel should remain permanent, it would be of great service to shipping, both as regards distance and depth of water.

The project for the cutting of this channel having been duly approved by the Chief of Engineers, a contract for the requisite amount of dredging was awarded to Messrs. Curtis & Fobes. Work was commenced during the early part of September, 1874, and continued until the latter part of the May following, when the contract was completed, a channel 100 feet in width at bottom and 9 feet in depth at ordinary low-tide having been secured. About 95,000 cubic yards of material were removed to accomplish this.

During the remainder of this fiscal year, and, in fact, until dredging was resumed at the Horseshoe the following August, the suction-dredge was engaged in dredging in this new channel, particularly at the upper end of the cut, where there was a slight tendency to shoal.

The suction-dredge not only maintained the full depth of 9 feet, but slightly increased it.

The next most interesting portion of this year's operations was the resumption of work at the "Logs," above Campbell's Island. As stated before, one cut and about one-third of another had been made across the "Logs" (proper) during the previous fiscal year. Work was resumed here on December 17 (1874) with one large dredge, fitted up with grappling apparatus, and continued until the last week of the June following.

During the last four weeks of this time an additional dredge was employed. The result of this work was the completion of 6 cuts across the "Logs," the cuts aggregating 245 feet in width; and, at the shoal below the "Logs," 3 cuts entirely across, aggregating 125 feet in width. The character of the bottom at the "Logs" has already been described. At the shoal below the bottom was found to be somewhat different. The stumps met with were not as numerous as at the "Logs;" but those encountered were mostly larger and much more difficult to be removed. Much of the material was taken up by the ordinary bucket without the aid of the grapple, and was dumped through ordinary scows. The stumps and larger roots were loaded and removed on decked scows. Twelve feet of water at ordinary low-tide was thus secured entirely across the "Logs" and the shoal below, which is an increase of 3 feet over the original depth.

During this year (1874-'75) the suction-dredge worked continuously from August 13 at the Bald Head Channel, except during the time mentioned above, when she was engaged at the Horseshoe cut. The dredge is not well adapted to working in rough water, and much time was lost by her on that account. Under the most favorable cir-

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cumstances, she was able to remove, carry well over the bar, and dump 160 cubic yards of sand per day. This would be at a cost of just about 25 cents per yard, provided no *lost time* came in to increase the average cost.

The probability is that the sand stirred up by her shoes and carried away by the current amounted to many times as much as that absolutely removed by the pump.

At the close of the fiscal year there were to be found 11½ feet of water on the Bald Head Bar at ordinary low-water; an increase of 18 inches during the year. At the jetty at Federal Point nothing was done during the year, except to replace 8 *top* cribs which had floated away, the worms having destroyed the bottom planking.

At the old works, between Smith's and Zeke's Islands, the accumulation of sand was immense, and at last the 2 islands became connected by a continuous beach. About one-half of the work became covered with sand, and a regular sand-beach formed on the inner or river side of the work, thus effectually protecting this portion of the work from further damage by worms. An abrasion of the point of Smith's Island, below the old works, led to the construction of about 1,300 feet of narrow crib-work for its protection. This work was done during May and June, 1875.

During the fall of 1874, the water on the Bald Head Bar having become manifestly better than that on the rip of the western channel, the latter was abandoned by shipping and the former came into general use. The result was that the lightening of vessels, which was formerly carried on in an exposed position, between the rip and the bar of the western channel, was now carried on in the river, in front of the village of Smithville, at a greatly-reduced cost.

During the fiscal year just ended (June 30, 1876) an important step was taken at the New Inlet.

At the beginning of the year, the 500 feet of jetty at Federal Point had been standing for a period of 18 months. Its effect upon the inlet, and upon the river below, had been carefully watched, and no new developments were anticipated. The new cut behind the Horseshoe was standing well, and drawing a large quantity of water toward the western side of the river. The improvement at the "Logs" had provided as much water in the upper river as could be carried over the bar, and the time seemed ripe for attempting a further contraction of the inlet.

Proposals were accordingly invited for continuing work at the inlet, either by undertaking the closure of the inlet as a lump job, by extending the old jetty to a specified length, or by constructing an apron entirely across the inlet.

In case bids were to be made for the latter, bidders were to be governed by drawings, (made under the direction of the officer in charge of the work,) showing plan and sections of such an apron as seemed to the Government to be desirable, referring to dimensions only, and not specifying the class of material to be used, and the method as well as the extent of work they were willing to undertake.

After some delay, caused by the rejection of one entire set of proposals, a contract was, on the second opening of bids, awarded to Bangs & Dolby, of New York State, for the construction of an apron entirely across the inlet. The apron was (in accordance with the Government drawings) to vary in width with the depth of water at the various points on the proposed line of work. This gave, at the deepest water, a width of 70 feet; at the shoalest, a width of 40 feet; average width, 53 feet. This width was such that if the structure were brought up with a slope of 1 on 2 on the sea-side, and 1 on 1 on the river-side, it would have a width of 16 feet at ordinary low-water mark. The apron was to be 4 feet in thickness, and was to consist of 1 layer of round timber 1 foot in thickness, 1 layer of brush 1 foot in thickness; the remaining 2 feet to consist of stone.

The apron was to follow the line laid down by the officer in charge of the work, and the contractors were to guarantee the permanence of the structure for the period of 1 year.

The line laid down for the apron was broken, and consisted of 3 sections. The first, 920 feet in length, was on the prolongation of the line of the Federal Point jetty; the second, 1,588 feet in length, ran along the crest of the 6-foot shoal, in a direction nearly tangential (a little outside) to Zeke's Island; the third, 1,844 feet in length, crossed the inlet channel and rested on the shore of the island at the site of Woodbury's old wharf.

Total length of apron, 4,352 feet.

The contract for the execution of the above work was dated August 25, 1875. Work was commenced early in October, 1875, and the entire work was satisfactorily completed about the middle of June, 1876. The apron consists of successive rafts or mattresses of timber and brush, sunk in juxtaposition on the line of work. The mattresses average about 40 feet in length, measured on the line of work, and in width correspond with the required width of apron. The timbers are placed lengthwise *with* the current, or *across* the line of the work.

But little if any settlement occurred after a mattress was once in position. There was, however, a tendency to scour in advance of the line of work, so that the individual mattresses were sunk (on an average) in nearly 3 feet more water than the

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original soundings called for. In calculating the required width of the apron, before the work was commenced, an allowance of 2 feet was made for the anticipated scour.

There has also been a tendency to scour along both sides of the apron, particularly on the river-side of the second section. This has been so slight as not to jeopardize the work, and shows that the first section of the apron, in conjunction with the Federal Point jetty, is doing good service as a deflector of the ebb-currents.

While the New Inlet apron was in course of construction the new channel behind the Horseshoe Shoal was being widened and deepened. A contract for this dredging was awarded to Messrs. Curtis & Fobes. Work was commenced on August 9, 1875, and completed on May 13, 1876. The result of this dredging was the enlargement of the channel to 190 feet in width at bottom, and to 12 feet in depth at ordinary low-water. A little over 280,000 cubic yards of material were removed to accomplish this. The channel stands well, except at the upper end of the cut, where there is a tendency to shoal, as was the case with the 9-foot channel. It is reported, however, by the assistant in immediate charge of the work (M. H. Bacon) that, since the completion of the apron at the inlet, this tendency to shoal has diminished. The new channel has also come into general use; and it is believed that the frequent passing of propellers will keep the channel open at this point, as did the suction-dredge during the interval between the completion of the 9-foot channel and the commencement of dredging to 12 feet in depth. At all events, the channel should be *kept* open as long as further operations at New Inlet are contemplated, even if a considerable annual expenditure is thereby involved.

The construction of the apron at New Inlet and the enlargement of the Horseshoe Channel constituted the principal work of the late fiscal year.

Of the minor operations, the removal of the confederate obstructions before the city of Wilmington was the most important and interesting.

These obstructions were located about 3 miles below the city of Wilmington, N. C. They consisted of rows of grillages, loaded with stone sufficient to keep them in position, with timbers 10 by 10 inches inclined down stream at an angle of 45°. These timbers came nearly up to low-water mark; were provided with iron points, and were placed at intervals of 5 feet. They were mortised into the up-stream side of the grillages, but were so slightly held that it was expected they would turn, as on a hinge, as a vessel advanced upon them, until, as they approached a vertical position, their penetrating power would be increased.

Off these grillages, 2 rows existed on the eastern side of the channel, and 1 upon the western side, aggregating about 500 yards in length. In addition to these, a quantity of railroad-iron had been pointed and arranged in the form of chevaux-de-frise, and put in (without much regard to order) about the ends of the rows of grillages toward the channel, leaving a very narrow passage.

These obstructions were removed during the months of July and August, 1875. The pointed timbers were broken from their mortises by means of a tug pulling up stream with a hawser attached, and the iron chevaux-de-frise were removed by means of tackling attached to the temporary yard-arm of a schooner, chartered and rigged for the purpose.

The grillages could not be upset with the appliances at hand, and were left at the bottom; but they in no way impede navigation, there being 14 feet of water over them in the channel at low-water.

The suction-dredge continued her operations on the Bald Head Channel until the 1st of February, 1876, when she was laid up, her boiler having become too old for service and her hull being badly worm-eaten.

On the completion of dredging at the Horseshoe Channel, 1 of the dredges was employed for about 10 days in trimming up at the lower end of the cuts across the shoal below the "Logs," and in cutting through a short shoal which had formed immediately above the upper eastern jetty, and just below the site of the confederate obstructions referred to above. The formation of this shoal has been attributed to the presence of the obstructions above. If this theory be correct, as seems likely, there will be no recurrence of the shoal.

During the year the depth of 11½ feet at ordinary low-water has been maintained on the Bald Head Bar. While this is no increase upon the depth reported a year ago, there has nevertheless been a marked improvement of the bar. Since the re-opening of channel there have been on the bar what are known as the inner and outer "lumps." The latter has deepened to fully 12 feet, and the inner lump has become so narrow that rarely more than 1 sounding, as small as 11½ feet, is obtained while passing over the bar with a tug-boat at half speed, which goes to prove that the bar has not yet reaped the full benefits of the works above.

This historical sketch of the Cape Fear River improvement is now brought up to the present date.

It may not be uninteresting, in conclusion, to briefly recapitulate the improvements to navigation which this most interesting work has already secured. From the bar of the river to the city of Wilmington 12 feet of water can be carried at ordinary

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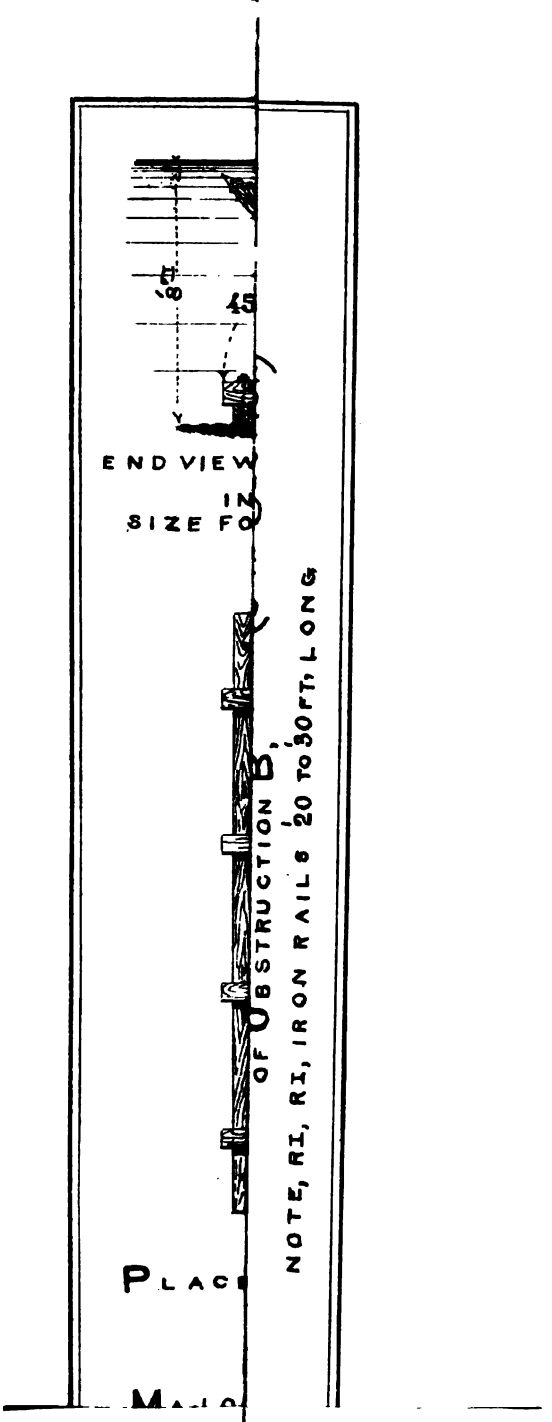

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low-tide. This is an increase of over 3 feet since operations were commenced in the fall of 1870. The principal merit of this part of the improvement is that it has every appearance of permanence, excepting, possibly, at the cut behind the Horseshoe.

This channel *may* depend for its security upon a further contraction, or the entire closure of New Inlet.

There is no record to show positively that this depth of water to the city of Wilmington ever existed before. It certainly has not during the last 54 years.

The restoration of the old Bald Head Channel secures a better entrance to the river than it has had since the report of Mr. Fulton in 1823, when he says that "vessels drawing from 15 to 16 feet of water may pass over the bar at high water in perfect safety." This class of vessels can and are doing so now. The permanence of this improvement depends, no doubt, upon the security of the work already completed in the vicinity of New Inlet. At the old works nature is every day adding to their security, by the immense quantities of sand which is accumulating there.

At the inlet we have a structure entirely across it, with its permanence guaranteed for the period of 1 year from date; and, although it is true the water-way of the inlet is contracted but little by it, yet, looking to the future, we may regard it (as it was intended to be) as a substructure which may hereafter be raised to any desired height, even to the entire closure of the inlet, if funds are provided for the purpose.

Respectfully submitted.

CHAS. B. PHILLIPS,
Captain of Engineers, U. S. A.

Maj. WM. P. CRAIGHILL,
Corps of Engineers, U. S. A.

F 14.

AQUEDUCT BRIDGE OVER THE POTOMAC RIVER.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., March 8, 1876.

GENERAL: On the 9th of February I was notified that I had been detailed by the Secretary of War to make an examination of and report upon the condition of the Aqueduct bridge over the Potomac River, in pursuance of a resolution of the Senate in the words following, viz:

IN THE SENATE OF THE UNITED STATES,
February 3, 1876.

Resolved, That the Secretary of War be directed to detail, as early as possible, an officer of Engineers to make an examination of and report upon the present condition, as respects safety and permanency, of the Aqueduct bridge over the Potomac River, at Georgetown, D. C.

Attest: GEO. C. GORHAM,
Secretary.

I inspected the bridge in person February 14, and then arranged for a thorough critical examination of all its parts as to which there was any apprehension of weakness. This examination was made by my direction, in a very careful manner, by Lieutenant Turtle, of the Corps of Engineers, whose report and drawings are herewith forwarded.

I trust to be excused for remarking here that the duty imposed by the resolution of the Senate has been deemed one of delicacy and responsibility, which I should much prefer had been committed to some other person. There are conflicting interests, the one desiring the positive condemnation and removal of this bridge, and the other insisting upon its retention, or upon payment of damages for its removal. Disregarding this cause of probable dissatisfaction with any judgment given by me on this subject, I cannot lose sight of the importance of reaching a correct conclusion with reference to a structure upon which human lives are daily put in jeopardy if it be not entirely safe.

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The act of Congress approved July 27, 1868, (Statutes at Large, vol. 15, page 231,) specified the condition on which certain tolls could be collected by the persons controlling this bridge. The condition was the certificate of the Chief of Engineers of the Army that the bridge was so far completed as to be ready, fit, and convenient for the passage of persons, animals, and vehicles. This certificate was given January 9, 1869. (See attached copies as follows, viz: Two letters of Maj. N. Michler, Corps of Engineers, dated January 2, 1869, and January 8, 1869, and letter of Chief of Engineers, dated January 9, 1869.)

The bridge has been in almost daily use since, and has borne, without accident to life or limb, as far as I can ascertain, the strains brought upon it by ordinary travel; but it has also been subjected to severe tests on occasions which have caused crowds of people, on foot and in vehicles, to cross it, going to and returning from the national cemetery at Arlington. No accident has happened on any of these occasions, as far as I can learn.

The material of which the bridge is built is subject to decay, and has decayed, as Lieutenant Turtle's report shows. Watchfulness and prompt replacement of decayed parts would go far to maintain the original strength of the structure. Without these there is constant danger. Extensive repairs are now in progress, and are intended to be thorough, I am informed. Summarily, the bridge in its present condition cannot, in my judgment, be considered safe. If thoroughly repaired and adjusted according to the present plan, it will be as safe as the certificate of the Chief of Engineers stated it to be in 1869, and as severe trial and use have since shown it to be.

The present plan and arrangements of the bridge are not the best, and are barely admissible for such a structure with the relations it has to the capital city of the nation, or to any important city, where not only strength but sightliness should be considered.

The "permanency," or, in other words, the continued safety of the structure, can only be assured by unremitting attention to keeping all its parts in thorough repair and adjustment, and the enforcement of proper regulations for its use on all occasions, and especially when the occasions are extraordinary and subject it to unusual strains.

The stone piers of the structure are entirely safe.

Mr. Dungan, representing the bridge company, courteously offered me, both by letter and in person, every facility for a thorough examination of the bridge.

Very respectfully, your obedient servant,

W. P. CRAIGHILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF LIEUTENANT THOMAS TURTLE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., March 8, 1876.

MAJOR: I have the honor to submit the following report of an examination made of the Aqueduct bridge at Georgetown, D. C., in pursuance of a resolution of the Senate requiring a report "upon the present condition, as respects safety and permanency," of this bridge.

With respect to the permanency of the bridge, it can only be said that, being of wood, it is subject to the decay and deterioration of bridges of its class, and that to be kept in order it must receive constant repairs. The necessary repairs, however, being made,

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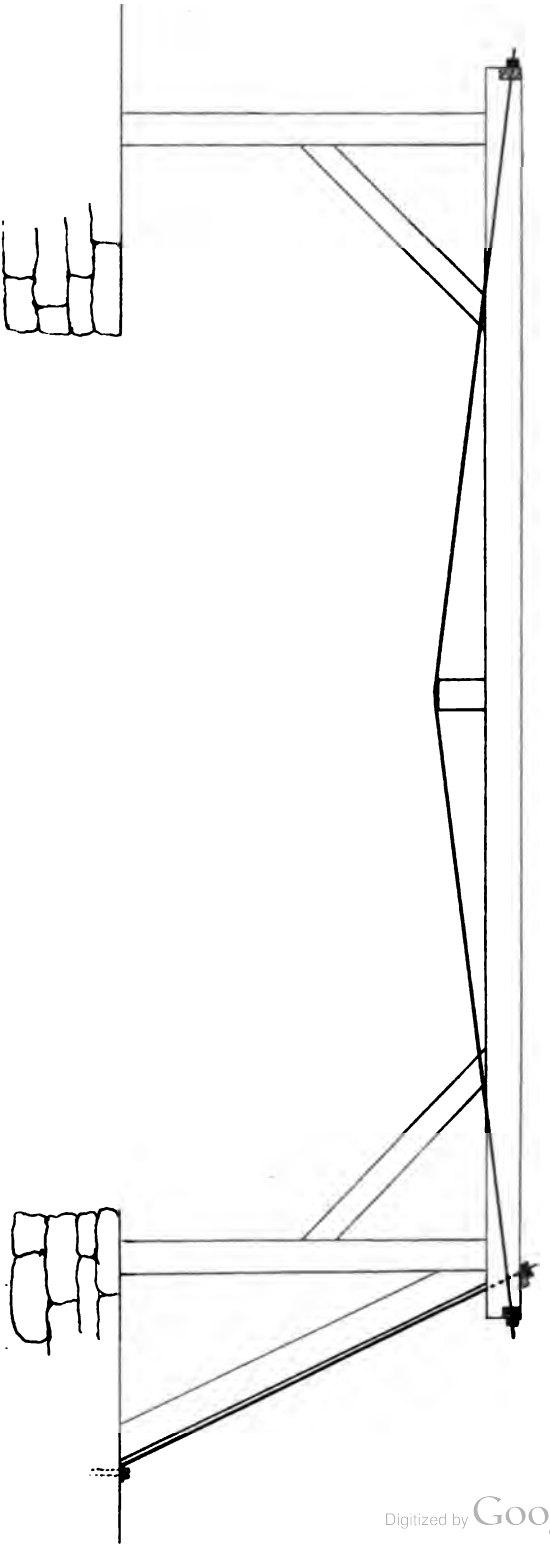

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will insure its permanency indefinitely; provided, of course, that it be originally of sufficient strength for its uses.

The present lessees were authorized by act of Congress, approved July 27, 1868, to collect in advance certain tolls "as soon as the Chief Engineer of the Army shall certify to the Secretary of War that the said bridge is so far completed as to be ready, fit, and convenient for the passage of persons, animals, and vehicles." The Chief of Engineers certified to that effect on January 9, 1869, since which time the bridge has been continuously operated for the passage of persons, animals, and vehicles.

I have learned of no accident since its opening, and the bridge must receive the credit for the service performed; which shows that for a period of seven years its safety has been proven by its success. Repairs were in progress during my inspection, and upon the thoroughness of those repairs depends the future safety of the bridge.

From the Georgetown to the Virginia shore the bridge consists of various parts, viz:

1st. An abutment and two lengths of 12 by 5 inch longitudinal floor-joists, with cross-planking supported upon trestles.

2d. A single length of truss spanning the canal and connecting with—

3d. A series of trestles extending across the approach to the aqueduct, supporting the roadway above.

4th. The nine spans of trusses over the river to the Virginia shore, and—

5th. A series of trestles connecting with an abutment on that shore.

The various parts will be considered in turn.

1st. The abutment is in very poor condition. How much of this condition is due to late street improvement I cannot say. The longitudinal floor-joists which support the planking are in poor condition, so much so as to be unsafe, and should be overhauled at once. Some of these are broken. The planking is very poor.

2d. The joists of the bottom chord of the up-stream truss are all parted, showing that the truss requires screwing up. The timbers of this chord are generally sound. I found two places showing rot, but not seriously damaged. The upper chord of this truss is rather worse; four or five of its timbers should soon be renewed. Two of the counter-struts are poor, and one is displaced from its bearing. The screwing up of the truss would remedy this latter. One strut is somewhat crushed at its upper end, and one is shaky; the latter was probably made from a bad piece of timber.

The bottom chord of the down-stream truss is generally in good condition as regards soundness, but its shore-end is crushed and shaky, and insecure on its support. The upper chord of this truss has one very bad timber and some shakes. Others of its timbers are more or less decayed. *Débris* collected near the river-end of the lower chord has somewhat rotted it. One post at the shore-end is partially rotten and cut away. One post at the river-end is poor. One strut is rotten and two counter-struts are shaky. The truss should be screwed up, two of the counter-struts being loose from their bearings. A large hewn timber under the river-ends of these trusses is "sagged" in the middle, causing the supporting-posts of this timber to incline inward at the top.

With proper care and watchfulness, I should anticipate no present danger to this section under the strain of ordinary traffic, if the shore-end of the lower chord of the down-stream truss be secured, the trusses screwed up to proper bearings, and the rotten strut renewed. The other defects should be remedied in the near future.

3d. The trestles of this section which support the roadway are constructed as shown by the accompanying sketch. The sketch is an elevation looking toward the river from the Georgetown shore. All these trestles are more or less "sagged." The iron rods along the struts on the up-stream side are bent to a horizontal eyelet at the lower end, through which passes an iron pin set in the coping. The top of the iron pin was then bent outward as shown in the sketch. All these rods are of little value, some of them none whatever, for the only purpose they can possibly fulfill, that of preventing the bending down of the cap-timbers of the trestles by holding the post in a vertical position. This entire section is unsafe and insecure.

Major Michler, in his report to the Chief of Engineers, dated January 2, 1869, speaks thus of this (the northern) approach to the bridge:

"The trestle-work at the north end is but a temporary substitute, and will be replaced, so the secretary and treasurer of the company informs me, by iron posts and girders."

No steps have been taken to carry this project to a conclusion, though it is now seven years since. Major Michler further states: "The company promise to render the approaches safe and secure."

4th. This section sustains the roadway, which is supported on the top chords, and the aqueduct-trunk, which is supported directly by the lower chords of the trusses. Both must be considered in discussing the question of safety. Accompanying this report is a tracing copied from drawings of the company, showing the construction of these trusses.

The bridge as first constructed was composed only of those portions shown by full black lines. Afterward, the arch-ribs, with their adjuncts, shown by the red lines

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were added. Still later, (I should judge, as the addition is shown only in pencil on the drawings from which the copies were taken,) the string-piece, with struts, shown in broken black lines on the elevation of trusses, was added as supports to the aqueduct-trunk. Studs were introduced between this string-piece and the cross-timbers, upon which the aqueduct-trunk rests. This string-piece is "sagged" more or less in all the spans, and to make up for this sagging the studs in many instances are supplemented by blocks to increase their length. Altogether this last addition is too slight to be with safety considered in the stability of the structure, especially as all the cross-timbers resting on the lower chords and supporting the aqueduct-trunk are either bent or broken. These cross-timbers affect the roadway but very remotely, and are to be considered very little in the safety of the latter. The dotted black lines in the cross-section, though shown in the original drawings, do not exist. The project for carrying a railroad over has not been carried out, and the side railings are supported by posts attached to the end of the cross-timbers or joists supporting the roadway. These joists extend only to the outer side of the trusses, as shown.

The red lines show the parts pertaining to the arch-ribs. The inner ribs are as shown in the drawing. I should judge that it was the intention that the outer ribs should also be as shown, but the rise was made greater than anticipated, and the tops of the ribs come nearly or quite up to the top of the upper chords of the trusses. As a consequence, it has been necessary to partially cut away the upper stick of the outer ribs to admit the washer, nut, and end of the two cross-rods connecting the upper chords at the middle of the span, thus to some extent injuring the strength of the ribs.

The upper sticks of the arch-ribs have also been cut into, to provide horizontal seats for the blocks upon which the washers rest. It will be observed that the assistance rendered by the arch-ribs to support the weight of the structure and its load depends entirely upon the relative degree to which the vertical rods pertaining to the arch ribs and trusses are screwed up. This assistance may be nothing, or the entire strain may be thrown upon the ribs, or the entire strain may be thrown upon two ribs, one at each truss.

In an imperfect combination of this kind the entire structure may fail through the successive failure of its parts from imperfect adjustment, even though the structure, taken as a whole, may be amply capable of sustaining the strain to which it is subjected.

The proper adjustment depends entirely upon the care and watchfulness of the bridge company, and cannot be predicated in advance. The attention which the matter deserves is scarcely to be expected if we take the care evinced in the past as a criterion by which to judge of the future. Most of the rot found at the lower extremities of the struts and counter-struts of the down-stream trusses, and in the lower chords, near these extremities, as well as over the piers, is due to the accumulation of *débris* permitted at these places. In at least one instance grass was found growing in the soil formed by the dust and droppings from the tow-path there collected.

The conditions of the various parts as found by the examination will now be given; the spans being taken in order from the Georgetown end. The elevations and plans in the drawing are taken looking down-stream, and the tow-path in the cross-section is on the down-stream side. The references are made to the drawings by the figures corresponding to the points.

FIRST SPAN.

Down-stream truss.

At 1, counter-strut loose.

At 2, everything is very rotten from the accumulation of *débris;* lower timber of outer arch-ribs slightly decayed where it abuts on pier.

At 3, outer strut rotten and poor.

3 to 5, one timber of chord rotted where abutting against another.

At 4, counter-strut rotten on the end; outer strut shaky at the end; inner strut better; outer end of timber for arch-rod pretty bad, shaky and rotten.

At 5, plate broken; outer strut crushed.

At 6, chord is decayed from *débris* to perhaps an inch in depth. Outer end of timber for arch-rod pretty bad, shaky and rotten.

7 to 11, some sap-rot in one timber of chord.

At 8, outer strut rotten at foot.

At 10, chord somewhat decayed.

At 14, outer strut rotted.

At 13, plate broken.

14 to 16, lower chord bad; one timber is badly shaken at end; chord seems, as seen from river below, to have considerable rot near abutment. There is a poor place near middle of lower chord; evidently too much cross-strain on the chord. There is a bad skake in the second timber (from top) of outer arch-rib.

At 16, counter-strut rotted.

At 17, plate broken. The upper chord has an open joint between 1 and 3.

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17 to 19, some sap-rot in one timber of chord.
At 18, timber for arch-rod shaky at end. Washer-seat of upper end of arch-rod crushed into arch-timber, very bad; upper timber of outer arch of Virginia end is a poor stick, shaky over 18. This rib is generally poor on top.
At 20, all rotted badly.

Up-stream truss.

At 2, one strut pretty rotten; the two others somewhat. Some decay in post.
3 to 5, chord slightly decayed.
At 4, struts crushed, and supporting-beam of arch-rod bent. Timber for arch-rods is very bad.
At 5, middle strut bad. Plate crushed into chord.
At 6, one strut decayed about an inch deep. A timber of the chord, extending from 4 to 10, is decayed somewhat. Washer at upper end of outer arch-rod is crushed into the rib. The timber of the rib below this is shaky. Lower chord shows badly throughout as seen from river; shaky and rotten near the under plates, and plates crushed into chord.
7 to 9, one timber of chord slightly decayed.
9 to 11, one timber of chord slightly decayed.
At 10, counter-strut rather poor.
At 14, one strut quite shaky and slightly decayed in one corner.
At 15, upper side of top chord is bad near here; one timber much rotted.
At 16, timber for arch-rods has a shake.
At 17, plate broken.
17 to 19, some decay in one timber of chord.
At 18, struts somewhat shaky, but sound. Timber for arch-rods is a bad stick.
At 20, struts and posts very slightly decayed.

SECOND SPAN.

Down-stream truss.

1 to 3, some sap-rot in chord near 3.
At 2, all timbers rotted; chord in very bad condition.
At 4, counter-strut slightly rotted; struts crushed and shaky, outer one slightly decayed.
At 6, chord slightly decayed.
At 8, one strut slightly decayed on one corner.
At 9, inner strut slightly out of place. The upper chord of this span has a joint open between 15 and 17, and two timbers with slight sap-rot.
At 10, struts and counter-struts slightly decayed. The entire end of timber for arch-rods bad.
At 12, bad shake in timber for arch-rods.
At 14, very slight decay.
15 to 17, some sap-rot in chord.
17 to 19, some sap-rot in chord.
At 16, outer strut somewhat rotted and very shaky. End of timber for arch-rod bad. Outer arch-rib somewhat warped from truss, and shaky in top timber.
At 18, inner strut very bad, and counter-strut pretty bad.
At 20, all very much rotted; chord very bad.

Up-stream truss.

Over pier a plate is required on upper side top chord.
1 to 3, considerable sap-rot in one timber of chord.
2 to 4, one timber of chord quite bad.
At 2, one post and inner strut slightly decayed.
At 3, top chord is parting on upper side; the plate is displaced.
At 4, chord is rather poor on under side; some rot, and shaky.
4 to 6, some decay in one timber of chord.
At 5, two timbers of top chord rotted; plate broken; inner strut pretty shaky.
3 to 5, one timber of top chord rotted some on upper side.
5 to 7, some rot on upper side top chord.
7 to 9, bad shakes in upper side top chord.
At 6, strut slightly decayed. Timber for arch-rods slightly shaky, but free from rot.
10 to 12, some decay round irons.
12 to 14, some decay in chord.
14 to 16, one timber of chord has a bad place.
At 8, lower plate crushed into the chord and one timber splintered. This must have been a poor timber when put in place.

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At 12, timber for arch-rods quite shaky on top, but free from rot.
16 to 18, lower chord is very poor on the under side. Some rot and shakes in three of the chord-timbers.
17 to 19, very slight sap-rot in chord.
At 18, one strut decayed somewhat.
At 20, post quite rotten; also two of the struts. Plate crushed into the chord.

THIRD SPAN.

Down-stream truss.

At 2, very rotten.
At 4, counter-strut quite rotten. Under plate, lower chord, crushed into the wood; some rot here; a bad place.
At 8, the timber for arch-rods is pretty shaky, but free from rot.
At 10, slight decay. Timber for arch-rods is bent downward in the middle, and is split by the bending.
At 12, chord slightly decayed. The timber for arch-rods is shaky and bent at the outer rod.
At 14, counter-strut and inner strut decayed.
At 16, counter-strut shows some decay.
At 18, chord rotted to about an inch in depth. A bad shake runs through the timber for arch-rods.
At 20, struts pretty bad. Chord over pier pretty bad. The upper chord of this span has one broken timber, and one joint open between 1 and 3.
17 to 19, one timber of chord broken across the grain; joint parted about ¼ inch. Outer arch-rib badly sprung from truss at Virginia end.

Up-stream truss.

Upper side of top chord over pier shaky.
1 to 3, upper side top chord shaky.
At 2, the plate is crushed into the chord about 2 inches. One post quite rotten; struts slightly so.
At 4, one strut somewhat shaky. Timber for arch-rods slightly shaky.
4 to 6, two timbers of chord are poor.
At 6, one strut has considerable sap-rot on one corner. 9 to 15. Up-stream timber of chord somewhat decayed; between 11 and 13 it is pretty bad. Some sap-rot in chord all along to 19.
At 14, one strut slightly shaky. Timber for arch-rods slightly shaky.
At 18, one strut pretty bad. Timber for arch badly shaken, but free from rot.
At 20, the chord is a good deal decayed; struts and one post slightly so.
At 15, rotten place on upper side top chord, near here; one timber bad.

FOURTH SPAN.

Down-stream truss.

At 2, very bad.
At 4, outer strut pretty bad.
At 6, outer strut somewhat decayed; counter-strut pretty bad.
At 8, pretty bad; outer strut very shaky and much rotted.
At 9, inner strut misplaced. 9 to 11. Slight shake in end of one timber of chord.
At 10, struts rotted quite badly. The timber for arch-rods is broken inside truss.
At 12, counter-struts poor at lower corners.
At 15, outer struts slightly crushed.
At 16, iron plate crushed. End of timber for arch-rods is badly shaken, rotted, and crushed, and the timber is broken in two.
At 18, very bad; struts crushed, counter-struts rotted. Cross-brace is loose.
At 20, chord quite bad; struts and counter-struts rotted.
Top timber of outer arch-rib quite shaky on Virginia side of arch. Outer arch-rib somewhat warped from truss at Georgetown end.

Up-stream truss.

The washers on top chord over the pin are drawn down into the timber, the wood being rotten under them.
At 2, struts slightly decayed; one post considerably rotted.
7 to 9, some sap-rot in chord.
At 9, considerable rot shows on upper side top chord.

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8 to 10, two timbers of chord decayed some.
9 to 11, considerable sap-rot in chord.
At 10, a shake about half through, at end of timber for arch-rods; timber for arch-rods broken in two in middle.
At 12, chord is poor; cross-timber under trunk of aqueduct broken nearly in two; timber for arch-rods is bent downward in the middle.
At 14, two timbers of chord poor; plate broken.
At 15, plate broken.
13 to 15, chord very little decayed.
At 16, timber for arch-rods is very bad. The strut, from pier to lower chord, is a bad timber, rotten and shaky. Outer-arch rib is shaky on upper side of top timber.
16 to 18, one timber of chord poor.
At 17, rotted, and shaky on upper side top chord; a bad place. Inner strut badly shaken.
17 to 19, some rot where two timbers of chord abut. Washer at upper end of arch-rod crushed into the timber; below, the rib is shaky at joint.
At 18, under-plate of lower chord is badly crushed into the chord; the chord is rotted; a very bad place. The chord is very bad along to 16.
At 20, struts and posts slightly decayed.

FIFTH SPAN.

Down-stream truss.

At 1, upper chord pretty bad with sap-rot.
1 to 3, joist separated about ¾ inch.
At 2, much rotted; one chord timber, 2 to 4, rotted. One timber of upper chord drawn apart three-fourths of an inch. The outer arch-rib has some decay on the inside.
At 4, bad. Counter-strut rotted. Struts crushed and rotted. There is a bad split in the timber for the arch-rods.
At 5, the chord seems to have been crushed, and the crushed portion was cut out, and new wooden plate (¾-inch) put in to fill up under iron plate.
At 6, pretty bad; all rotted; plate cracked.
At 8, counter-strut somewhat decayed.
Chord between 8 to 10 has some sap-rot.
At 9, counter-strut of little use from deficiency of bearing.
At 10, somewhat decayed.
At 14, counter-strut pretty bad; all somewhat decayed.
11 to 15, inside timber of chord with some sap-rot.
At 13, plate broken.
At 15, plate broken.
15 to 19, outside timber very bad with sap-rot.
At 16, outer strut quite poor. The timber for arch-rods is bad throughout. Timber for arch-rods rotted and shaky on under side. This is a bad end.
At 17, struts splintered slightly.
At 18, cross-brace rotten. Timber for arch-rods rotted and shaky on under side. Timber for arch-rods very bad on under side, crushed, broken, and rotten at the end. Outer strut quite poor.
At 20, all bad; chord is poor in three of its timbers.

Up-stream truss.

At 2, struts and posts slightly decayed.
At 3, one timber of chord crushed somewhat.
At 4, timber for arch-rods badly splintered and shaky at one end.
3 to 5, some decay in one timber of chord.
5 to 7, one timber of chord decayed some, where it abuts against another.
7 to 9, some sap-rot in one timber of chord.
9 to 1, chord very bad; three of its timbers are crushed and broken.
At 8, one strut considerably decayed; one slightly; chord slightly decayed.
At 10, struts somewhat decayed. Chord under plate quite poor.
At 12, counter-struts pretty bad. Timber for arch-rods is bad. The under plate is crushed into the stick, and timber appears bent.
13 to 15, top chord shows very bad on upper side; the timbers are crushing up; one is almost useless, and one is very shaky. The chord looks badly on upper side from 9 to 15.
At 14, counter-strut bad. Strut somewhat shaky.
14 to 16, chord poor.

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16 to 18, three adjacent timbers of the chord pretty poor.
15 to 17, two timbers of the chord slipped by each other. Repairs apparently in progress.
At 17, one stick shows rot; top chord on upper side parting near here.
17 to 19, one timber badly rotted on upper side top chord.
18 to 20, one timber of chord decayed some.
At 20, middle strut somewhat decayed.

SIXTH SPAN.

Down-stream truss.

At 2, pretty bad; all the timbers are rotted. The outer arch-rib is somewhat decayed.
At 3, a piece has been taken out of inner timber of chord 1½ inch in depth to three-fourths of its width.
At 4, counter-strut pretty bad. Outer strut, slight sap-rot on one corner.
At 6, counter-strut pretty bad.
At 8, other strut very bad.
At 10, all timbers pretty bad.
At 12, counter-struts pretty bad. The timber for arch-rods is badly shaken at the end, and is bent downward in the middle; washer at upper end of arch-rod crushed into timber of rib.
At 14, outer strut pretty bad; rotted and shaky.
At 18, inner strut slightly rotted; plate broken.
At 15, plate broken. The upper chord of this span has one timber with sap-rot, one splintered somewhat, and one with a bad knot.
At 16, the timber for the arch-rods is badly split, a bad timber; outer arch-rib somewhat warped from truss at Virginia end.
At 20, one post good, rest of timbers rotted; chord over pier decayed.

Up-stream truss.

A shake shows near 13, on upper side top chord.
1 to 3, chord rotted badly where two timbers abut.
At 3, a slight parting shows on upper side top chord; plate broken.
At 4, one strut crushed some; counter-strut lacking.
At 6, one strut and counter-strut slightly decayed.
4 to 6, two adjacent timbers of chord decayed some; one of them is shaky.
9 to 11, some decay in chord.
At 12, one of the counter-struts slightly shaky; three timbers of the chord show decay; one is poor; timber for arch-rods slightly shaky.
At 14, one strut is somewhat shaky.
15 to 19, one timber of chord decayed; should be removed.
At 16, plate broken; chord shows some decay; timber for arch-rods shaky throughout this end.
16 to 18, chord shows some decay.
At 18, the lower chord as seen from the water is very bad, crushed and splintered. Apparently about 3 inches of chord has been cut away on under side and a plank let into the space, against which the under plate rests. Some sap-rot on under side of this chord. The upper side is also cut away to let in new wood to support plate at 18. This is a very bad place. Timber for arch-rods has a split on upper side to heart; the stick is sound, however. Outer arch-rib has a slight parting of timbers at Virginia end.
At 20, struts somewhat rotted. One post decayed some.

SEVENTH SPAN.

Down-stream truss.

1 to 5, outside timber of chord very badly rotted, (sap;) should be renewed.
At 2, all timbers rotted.
At 4, counter-strut and outer strut decayed, the latter badly; cross-brace gone.
At 8, there is a bad split half through the end of the timber for arch-rods.
At 16, outer strut pretty bad.
11 to 19, outside timber of chord somewhat rotted, (sap.)
At 12, plate apparently crushed down in the middle.
At 14, counter-strut slightly decayed.
At 16, outer strut pretty bad. Timber for arch-rods somewhat shaky on inside of truss.

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At 17, counter-strut crushed and sprung.
At 18, timber for arch-rod badly split. The rod (outer) is bent. Lower timbers of arch-rib show some decay on the inside. The under side of chord between 4 and 6 appears from the water to have a good deal of sap-rot.
At 19, counter-strut loose and plate loose. Throughout the bridge the bearing-plates of the counter-struts at 1 and 19 are of wood. The upper chord of this span has one timber with some sap-rot and one with a good deal of sap-wood.

Up-stream truss.

1 to 3, some decay in one timber of chord. This timber should be renewed.
At 2, one strut somewhat decayed.
At 3, a joint badly started in top chord near. Chord pretty bad around bolts; looks as if it might soon pull apart.
Between 1 and 3 some sap-rot shows on upper side, top chord. Frozen *débris* over pier prevents the examination of the chord. The lower chord of this span should be thoroughly overhauled.
At 4, one strut is very bad, a good deal splintered; counter-strut is rather poor.
3 to 5, joint open where two timbers abut. Some decay in chord. The decay to 9 is in one timber.
5 to 7, some decay in one timber of chord.
7 to 9, some decay in one timber of chord.
At 6, one strut shaky; chord is poor.
At 7, a shaky timber shows on upper side of top chord.
At 8, one strut bad; one decayed some; chord all along here is in a poor condition.
10 to 12, chord shows some decay.
At 12, chord shows some decay.
At 14, chord shows some decay; counter-strut also.
13 to 15, some decay in chord; one timber shaky.
At 16, counter-strut shaky and crushed some. Timber for arch-rods rotted away at end. The plate under the truss is crushed into the chord. This is a bad place.
At 18, struts very bad; splintered, crushed, and shaky.
18 to 20, chord somewhat decayed.
At 20, posts quite poor; outer arch-rib appears sprung from truss.

EIGHTH SPAN.

Down-stream truss.

At 2, very bad.
3 to 5, outside timber has some sap-rot.
At 4, counter-strut slightly decayed.
At 6, plate broken.
At 8, rather poor.
At 12, chord decayed; outer strut slightly; inner strut shaky.
At 14, the timber for arch-rods is broken in the middle. The strut from the pier to this end of truss is crushed at the pier, and loose from bearing under truss.
At 17, struts twisted out of bearing. The upper chord of this span has one timber rather bad with sap-rot.
At 18, struts crushed and shaky. The outer timber of chord has considerable sap-rot. The timber for arch-rods slightly shaky. The washer at upper end of rod is crushed into the arch-timber.
At 20, one post pretty good; the outer timbers rotted.

Up-stream truss.

Upper chord has one pretty bad timber at 17 and to 19; one bad timber about middle of span.
At 1, a shake in upper side of top chord.
Between 1 and 3, some rot upper side top chord.
At 2, one post rotted some.
2 to 4, chord poor in several places.
At 3, upper chord shows crushing in upper side.
At 4, one strut pretty bad. Timber for rods of arch-ribs shaky, but free from rot.
4 to 6, chord shows some decay near a washer.
At 6, one strut very bad; rotted and shaky and crushed. The crushing is due to the shake.
6 to 8, one of the timbers of the chord is slipping by the next, owing to rot around iron. Nearer 6, one timber is considerably decayed.
At 7, bad place on top of upper chord around bolts.

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At 8, one strut is bad in one corner.

At 10, some decay in the chord to 12; timber for rods of arch-ribs pretty shaky at the end.

At 12, counter-strut decayed some.

11 to 13, chord decayed and splintered where two timbers abut.

13 to 15, some decay in chord.

At 14, one strut is bad, rotted, and shaky; counter-strut has some sap-rot. The chord near the plate is bad; timber for arch-rods bad at end.

At 15, plate broken.

At 16, struts somewhat crushed, and one of them is very shaky; counter-strut decayed some. A poor place. Timber for rods of arch-ribs bad at end; shaky and slightly rotted.

At 19, one timber of chord slightly decayed.

At 20, struts and counter-struts slightly decayed; outer arch-rib somewhat warped from truss; lower chord at Virginia end looks badly from the water. It should be overhauled.

NINTH SPAN.

Down-stream truss.

1 to 3, an iron is pulling out; bolts probably require to be screwed up.

At 2, one post good, the other timbers rotted. The chord is bad.

At 4, outer strut is rotted, shaky, and badly sprung; must soon break unless replaced.

At 8, considerable sap-rot in one timber of chord.

At 10, chord pretty bad; one counter-strut bad.

At 12, the chord along here is very poor.

At 12, timber for arch-rods pretty shaky.

At 13, plate broken. The upper chord of this span has one timber with some sap-rot and one slightly splintered at the end.

At 14, there is a bad shake at the end of the timber for arch-rods.

At 16, the end of the timber for arch-rods is bad, (rotted;) chord has crushed into this timber. This is a very poor timber throughout. The lower chord down-stream truss appears badly from the water. The strut from the eighth pier to the Georgetown end of down-stream truss of ninth span is lacking.

At 18, counter-strut lacking.

At 20, the chord at the foot of those struts is in very poor condition, rotted and crushed by plate.

Up-stream truss.

Chord over pier cannot be seen on account of frozen *débris*.

At 1, posts loose.

At 2, one strut shows some decay.

At 3, one strut shaky; one timber of chord shows some decay.

At 4, one timber of chord has some sap-rot on one corner.

At 6, one strut with some rot on one corner; counter-strut pretty bad on under side.

At 8, inner timber of chord is very poor; 8 to 10, two inner timbers of chord decayed, poor; 9 to 11, some decay in chord, one timber bad.

At 7, counter-strut shaky; one timber of chord some decay; 11 to 13, two timbers of chord have some sap-rot; supporting-timber of arch-rod crushed.

At 12, counter-strut bad; inner strut shaky.

At 14, counter-strut, some sap-rot.

At 15, plate broken; some decay in one timber of chord; 16 to 18, where two timbers of chord about the ends, are very bad.

At 16, timber for arch-rods split from upper side half through. The outer arch-rib has its second timber from top crushed somewhat on the Virginia side of the crown. Outer arch-rib is somewhat warped from truss.

At 18, timber for arch-rod rotted on under side.

At 20, one post slightly rotted. Frozen *débris* prevents an examination of the chord. It is seen that those struts showing that they have been subjected to a strain nearly to their limit of strength are in the second sets from the piers. These sets are of two timbers throughout the bridge. The greatest strain is on the first set, but the precaution has been taken to introduce in the first sets a third timber, as an additional strut, consisting of two parts, the upper part extending from the plate at upper chord (at 3 or at 17) to the counter-strut, (1 to 4 or 19 to 18;) the second part supplements the first, extending from the counter-strut to the plate on the lower chord, (at 2 or at 20.) I estimate the weight of the structure, exclusive of the arch-ribs and the parts pertaining thereto, to be 104,000 pounds per panel. This includes the water in aqueduct. The aqueduct trunk being nearer the up-stream side, most of this weight will be

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borne by the up-stream truss. The weight borne by this truss, excluding the arch-ribs, would be 53,164 pounds per panel. This would produce a compression upon the second sets of struts (from formula given by Rankine, page 480) of 182,884 pounds. The area of the cross-section of each strut is 132 square inches; total, 264 square inches per set. The constant compression, then, due to the weight of the structure and to the weight of the water in the aqueduct, would be 693 pounds per square inch of the second sets of struts. The Ordnance Manual gives 5,017 pounds per square inch as the crushing force for the white pine of the Allegheny River, Pennsylvania. This bridge is built of Pennsylvania pine. This compression of 693 pounds per square inch was that borne by these struts before the introduction of the arch-ribs. The wave preceding the canal-boat acted as a moving load, but the effect of this cannot be estimated from any data we possess. Since the introduction of the arch-ribs the roadway was opened, and we have no data for the maximum load, stationary or moving, to which the bridge has latterly been subjected. Even if we knew this, the relative portion borne by the arch-ribs and the original trusses could not be known; but, as has been seen, most of it might have been borne by the latter.

That the trusses have been permitted to sag in the middle, is seen by those instances where the top chord over the piers shows indications of a strain of extension. These indications, with the crushing of struts in several instances, crushing of the top chord in one truss, (though probably due to defective timber,) and the warping or springing of the outer arch-ribs from the trusses at several places, show that the structure should be carefully overhauled before the filling of the aqueduct with water should again be permitted.

The cross-timbers, resting upon the upper chords and supporting the roadway, appear to be in very good order. The longitudinal 4 by 4 sticks, across which the planking is laid, were very poor, and rotten in several places. These rotted sticks were being replaced at the time of the inspection. How thoroughly it has been done I do not know. The planking of the bridge is very much worn in many places, but with proper watchfulness there is no danger from this cause. A number of the planks I found to be too short to reach the 4 by 4 longitudinal sticks on the down-stream side, next to the foot-path. This should be remedied. The side-railing was poor in several places. Repairs to it were in progress.

Fifth. The approach to the bridge on the Virginia shore is a temporary structure supported by trestles, consisting of a ground-sill, three vertical posts, and the cap-sill. This trestle-work is on the up-stream embankment of the approach, and is connected with the bridge proper by an oblique roadway, supported by longitudinal stringers, those in the middle of the roadway resting on posts; a very temporary structure, but strong enough for carriages and the lighter class of farmers' wagons, but is unfit for heavy traffic. The side-railing of this approach is poor in several places.

Respectfully submitted.

THOMAS TURTLE,
First Lieutenant Engineers, U. S. A.

Maj. WM. P. CRAIGHILL,
Corps of Engineers, U. S. A.

LETTERS OF MAJOR N. MICHLER, CORPS OF ENGINEERS.

1.

OFFICE OF PUBLIC BUILDINGS, GROUNDS, AND WORKS,
United States Capitol, Washington, D. C., January 2, 1869.

GENERAL: In compliance with the directions contained in letter of headquarters, Corps of Engineers, dated December 30, 1868, the following report is submitted of the inspection I was requested to make of the bridge being completed over the Potomac River at Georgetown, by the Alexandria Canal, Railroad and Bridge Company. A letter from Mr. William W. Dungan, secretary and treasurer of the company, was inclosed for my information, in which he called attention to an act of Congress relating to the Alexandria Canal, and stated that the bridge was ready for inspection in conformity thereto. Sections 2, 3, and 4 of said act, approved July 27, 1868, are as follows:

"SEC. 2. *And be it further enacted*, That the said lessees, their associates, their heirs and assigns, are hereby authorized and empowered to maintain and operate said aqueduct, and to erect, build, operate, and maintain, across the Potomac River, from Georgetown, in the District of Columbia, to the Virginia shore, upon and over the stone piers upon which the aqueduct now rests in conjunction therewith, a bridge of wood, iron, or stone, with one or more ways for the passage of persons, animals, and vehicles, and also with one or more tracks, or ways, for the passage of engines and cars, with such other conveniences as are usual or necessary for a railroad.

"SEC. 3. *And be it further enacted*, That it shall be lawful for the said lessees, their

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associates and successors, to lay out, construct, maintain, and operate a railroad across said bridge, from Georgetown, in the District of Columbia, to the Virginia shore, and there to connect with said railroad.

"SEC. 4. *And be it further enacted*, That as soon as the Chief Engineer of the Army shall certify to the Secretary of War that the said bridge is so far completed as to be ready, fit, and convenient for the passage of persons, animals, and vehicles, the said lessees, their successors, and their legal representatives, may demand, have, and receive, in advance, the following tolls, to wit," &c.

Agreeably to my instructions, I examined the bridge and its approaches on the day of the receipt of the letter, the 31st of December, as carefully as the state of the weather would permit. As the company desired an early inspection, in order to be able to open the bridge for tolls on or near the 1st of January, 1869, no exact measurements were made at the time of the different dimensions of the bridge, or drawings prepared of the plan and sections, but it is proposed to do so in the future, that they may be placed on file among the archives of the office.

The Potomac Aqueduct at Georgetown was constructed to carry the Chesapeake and Ohio Canal across the Potomac River, and was designed and partly executed in stone. It was built under the superintendence of Captain Turnbull, of the United States Topographical Engineers. The piers, every third one forming an abutment pier, are most substantially built of heavy blocks of gray limestone, laid in hydraulic cement, and upon them rests a wooden superstructure, consisting of the trunk of the aqueduct and tow-path. Above that, on the deck of the aqueduct, the bridge proper, composed of the roadway, footway, and parapets for the passage of persons, animals, and vehicles, is being completed. The bridge proper across the river itself consists of two trusses of the Howe combination, strengthened by arches and chords. The cross-joists or floor-girders of the roadway are placed upon the upper stringers of each truss. Although the wooden arches are made to abut against each other, an iron plate separating the ends, instead of being imbedded in the stone piers, still the entire upper structure is substantially constructed, and possesses the requisite strength and stiffness. The dimensions of the wooden beams which form the chords, strings, joists, diagonal braces and posts, and the iron bolts connecting the upper and lower strings, and the arches and chords are sufficiently large for the purpose. At the north end of the bridge proper a trestle-bridge carries the roadway over the canal and connects it with one of the streets of Georgetown. At the south end another trestle-bridge connects with the causeway leading to it.

The trestle-work at the north end is but a temporary substitute, and will be replaced, so the secretary and treasurer of the company informs me, by iron posts and girders. An embankment, sustained by a retaining-wall on the upper side of the canal, is to be substituted for the trestle-work at the south end. At present the approach to the bridge along the causeway is very narrow, but is being gradually widened, and the rise from the causeway to the level of the trestle-bridge is quite steep. Railings are still needed along portions of the latter. These defects are being gradually remedied, and the company promise to render the approaches to the bridge safe and secure. As the result of my inspection of the bridge proper, and in view of the work on the approaches being pushed rapidly forward, I have the honor to report that "the bridge is so far completed as to be ready, fit, and convenient for the passage of persons, animals, and vehicles."

Mr. Dungan's letter is herewith returned.

I am, very respectfully, your obedient servant,

N. MICHLER,
Major of Engineers, Bvt. Brig. Gen., U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers.

2.

OFFICE OF PUBLIC BUILDINGS, GROUNDS, AND WORKS,
U. S. Capitol, Washington, D. C., January 8, 1869.

GENERAL: In addition to the report which I submitted on the 2d instant, concerning the bridge being built over the Potomac at Georgetown, having been directed to inspect it for the reasons therein stated, I now beg leave to inform you that I again examined the work this morning, and find that the defects then existing have been entirely remedied. The approach to the bridge by the causeway, on the south side, has been leveled and sufficiently widened, and substantial railings have been constructed along it in order to guard against accidents. The entire bridge and its approaches are now safe and secure.

In conformity to the act of Congress relating to the Alexandria Canal, approved July

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27, 1868, a careful inspection has been made, and I beg leave to report in the words of an extract from section fourth of the act, that the "said bridge is so far completed as to be ready, fit, and convenient for the passage of persons, animals, and vehicles."

I am, general, very respectfully, your obedient servant,

N. MICHLER,
Major of Engineers, Bvt. Brig. Gen., U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers.

LETTER OF THE CHIEF OF ENGINEERS.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 9, 1868.

GENERAL: In compliance with the terms of section 4 of an act entitled "An act relating to the Alexandria Canal," approved July 28, [27,] 1868, expressed in the following words, viz: "That as soon as the Chief Engineer of the Army shall certify to the Secretary of War that the said bridge is so far completed as to be ready, fit, and convenient for the passage of persons, animals, and vehicles, the said lessees, their successors and their legal representatives, may demand, have, and receive, in advance, the following tolls," &c., I have caused an inspection to be made of the bridge over the aqueduct across the Potomac River from Georgetown to the Virginia shore, and do hereby certify that "the said bridge is so far completed as to be ready, fit, and convenient for the passage of persons, animals, and vehicles."

Copies of the reports of inspection by General Michler are inclosed.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General of Engineers, Commanding.

Maj. Gen. J. M. SCHOFIELD,
Secretary of War.

APPENDIX G.

ANNUAL REPORT OF MR. S. T. ABERT, UNITED STATES CIVIL ENGINEER, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., August 11, 1876.

GENERAL: I have the honor to submit herewith my annual report relating to the works of river and harbor improvement under my charge for the fiscal year ending June 30, 1876.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

G 1.

WASHINGTON AND GEORGETOWN HARBORS, DISTRICT OF COLUMBIA.

In the last annual report it was stated that—

As the work [of dredging] approached completion it was found that a balance would remain, which, by the conditions of the act of appropriation, might be applied to the removal of the dangerous rocks from the harbor of Georgetown. The subject was

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brought to your notice, and a chart of the rocks and specifications for their removal were laid before you. With your approval, the work was ordered to be advertised, but the period of execution will fall in the next fiscal year.

After allowing for contingencies, it was found that a balance of about $10,000 might be devoted to this object. The work was accordingly offered for contract. The following is an abstract of the bids received, which were opened at noon of July 30, 1875:

Number.	Name and address.	Price per cubic yard.	Time of commencement.	Time of completion.	Method of working.	Remarks.
1	American Dredging Co., Philadelphia, Pa.	$30 00	Sept. 1, 1875	June 30, 1876	Burleigh drill. Blast and dredge.	For not less than 300 cubic yds.
2	Francis H. Smith, New York.	29 00	Sept. 1, 1875	June 30, 1876	Divers and steam-drill. Vessel with derrick.	For 600 cubic yds.
3	J. Schuyler Crosby, New York.	27 65	Aug. 15, 1875	Dec. 31, 1875		
4	Edw. Moore, Portland, Me.	37 00	Oct. 1, 1875	June 30, 1876		
5	Thos. P. Morgan, Washington, D. C.	19 00	Sept. 1, 1875	April 1, 1876		
6	Geo. W. Townsend, Boston, Mass.	26 00	Sept. 1, 1875	June 30, 1876		

An examination of the machinery and methods employed for removing rock in James River indicated that the work could be done more cheaply by hired labor than by contract. As the funds available for rock-work in James River did not permit its continuance beyond October, 1875, Colonel Craighill offered the use of the drilling-apparatus, &c., for the removal of the rocks in Georgetown Harbor. The bids received were therefore all rejected. The transfer of the machinery was made, with your consent, during calm weather in December, 1875, and the derrick, lighters, &c., laid up for the winter behind Analostan Island. Work was commenced as soon as the weather permitted, (March 20,) and is still in progress.

The expenses for repairs were in excess of the estimates of the former superintendent on James River. The machines and plank had been in continuous use for several years, and many of the parts were in such a condition as to render their entire removal necessary. The work has, however, been done at less cost than the lowest bid, when offered for contract. Up to this date 336 cubic yards have been removed, at an average cost of $16.28. This includes the repairs made necessary by the breaking of the derrick. After raising the rock and placing it on the stone-barges, it is removed and deposited without further expense by the company constructing the inclined plane for lowering canal-boats from the Chesapeake and Ohio Canal to the river.

On rock A, just below the aqueduct, there is now 17 feet at low-water. On B, just above the prolongation of High street, there is now from 13 to 20 feet at low-water, where originally there was but 6. At G street wharf there is about 9 feet, where heretofore there has been but 3 feet at low-water.

The work on rock B will be resumed as soon as the sand and *débris* left after blasting has been removed. The practical details and analyses of the cost of the work will be presented in my final report on these operations.

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CONTINUATION OF THE IMPROVEMENT.

In my last report I enumerated the chief features in the plan of the Board, which was submitted to Congress December 17, 1872. It was evident that a plan of such magnitude must be executed in parts, and it became necessary to consider the whole plan, in order to determine what parts should be first selected for execution. In making this selection, it was important that the work to be done should, in itself, be an actual improvement of the navigation. It was also desirable that the partial improvement should make nature a co-worker in establishing the channel which engineers have decided to be the most suitable for navigation. In accordance with this criteria, an estimate was submitted for improving the river between the aqueduct and Easby's Point. An examination of the map showed that the river had been contracted between G street and Easby's Point by the construction of wharves, so that at this point its width was less than at any part of the channel between the point and the aqueduct. The effect of this contraction has been to increase the floods in Georgetown and to accelerate the deposit of mud in the channel below Analostan Island. Easby's Point has the further effect of deflecting the floods to the marsh at the foot of the island, from which a part of the current is directed toward the north end of the bridge. These objectionable effects would be largely modified by cutting off Easby's Point and the northeast edge of Analostan Island. The operations contemplated were limited to the part of the river between G street and Easby's Point. The total amount of the appropriation asked for was $564,000; of this sum, $14,000 were to be expended in dredging the Washington Channel between the arsenal and the Long Bridge. This channel, affording the only access for steamboats and shipping to the city wharves, is becoming shoaler each succeeding year. It will be necessary to keep it open by dredging until the improvement (according to the plan of the Board) is so far advanced that wharves can be erected on the Virginia Channel below the bridge. The old channel will then be occupied by streets and squares, 1,023 acres of land will have been reclaimed, and 37,000 feet of wharf frontage (including Eastern Branch) made available. The reclamation of the land necessary to effect these objects will convert the pestilential area between Easby's and Arsenal Point into spacious parks and valuable building lots. The execution of this part of the plan will require large and prompt appropriations, and its effects, as well as the details of the practical operations, should be well considered before it is begun.

* * * * * * *

In explanation of the following estimate for the work proposed at Easby's Point, I would state that the rock-excavation in the harbor of Georgetown, including transportation from Richmond and repairs of machinery, cost during the first month $21 a cubic yard; the net cost during the month of May (excluding the above contingencies) was $10 per cubic yard. The average cost of 250 cubic yards, including ordinary repairs, transportation of plank from Richmond, &c., was $15.30 per cubic yard. As the contingent expenses are nearly the same whether the amount of work done be small or large, the average cost per yard decreases as the work advances within certain limits.

In the work proposed near Easby's Point, it will be necessary to include the cost of machinery as well as ordinary contingencies of repairs and superintendence.

I have estimated the average cost per cubic yard for this work at $12. A reduction in the cost may be made by a careful organization and judi-

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cious conduct of the operations. I do not think it safe, however, in consideration of unforeseen contingencies, to estimate it at a less rate per cubic yard.

APPROXIMATE ESTIMATE FOR THE IMPROVEMENT OF POTOMAC RIVER AT EASBY'S POINT AND FOR DREDGING BETWEEN THE POINT AND DEEP WATER BELOW.

Earth-excavation, 2,400 cubic yards, at 30 cents	$7,200
Dredging, 60,000 cubic yards, at 40 cents	24,000
Rock-excavation, 44,400 cubic yards, at $12	532,800
Removing wharves	7,600
Contingencies	114,400
	686,000

RECAPITULATION.

The amount asked for is as follows:

For the work at Easby's Point	$550,000
For dredging at Washington Channel	14,000
	564,000

This amount, which would of itself make an efficient improvement, is the same as asked for last year.

The amount estimated for the work at Easby's Point and Analostan Island, in accordance with the plan of the Board, is $1,902,664. (See annual report of Chief of Engineers for 1875, part 2, p. 119.)

Money statement.

Amount available July 1, 1875	$20,755 24
Amount expended during fiscal year ending June 30, 1876	11,313 37
Amount available July 1, 1876	9,441 87
Amount that can be profitably expended in fiscal year ending June 30, 1878.	14,000 00

G 2.

ACCOTINK CREEK, VIRGINIA.

No funds have been available for this improvement during the year, and no work has been done.

The amount required to complete the work according to the original estimate is $14,000. The appropriation made June 10, 1872, was $5,000.

Accotink is in the collection-district of Alexandria, which is the nearest port of entry.

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G 3.

OCCOQUAN RIVER, VIRGINIA.

An appropriation of $5,000 was made by act of March 3, 1875, and the work offered for contract, the following bids having been received and opened June 30, 1875:

Number.	Name and address.	Removed in scows.		Deposited on sides of channel.		Total.	Time of commencement.	Time of completion.
		Price per cubic yard.	Amount for 7,000 cubic yards.	Price per cubic yard.	Amount for 13,000 cubic yards.			
1	A. A. Dodge, Baltimore, Md	$0 27	$1,890	$0 13	$1,690	$3,580	Sept. 10, 1875	Jan. 10, 1876
2	G. H. Ferris, Brooklyn, N. Y	General bid of 20 cents.				4,000	Nov. 1, 1875	June 30, 1876
3	Wm. H. Beard, Brooklyn, N. Y	24	1,680	18	2,340	4,020	Feb. 1, 1876	June 30, 1876
4	Thos. P. Morgan, Washington, D. C	22	1,540	15	1,950	3,490	Immediately.	Sept. 1, 1875
5	J. H. Toemyer & Co., Baltimore, Md	24	1,680	18	2,340	4,020	July 15, 1875	Nov. 30, 1875

Contract awarded to Mr. Thos. P. Morgan, of Washington, D. C.

The contractor, having been unable to complete other work on which he was engaged, was permitted to defer commencing until March 1, 1876. A channel was first excavated through the bar, about midway between the railroad-bridge and Occoquan, over which but 4½ feet could be carried at low-water. The material excavated was coarse sand, and was deposited on the edge of the upper mud, and below the bridge, in from 4 to 5 feet of water. The channel was completed April 15, with a width of 80 feet and a depth of from 5½ to 6 feet at low-water.

As this bar owes its formation to a sudden increase in the width of the river, and the consequent deposit of material brought down by freshets, the channel can hardly be expected to maintain its depth without the aid of a dike to contract the width of the river.

A survey of the channel through the haven mud at the mouth of the river was made April 8. It was found that owing to the accumulation of logs and drift-wood, and from other causes, the channel had filled in to such an extent that but little more than 4 feet could be carried through it at low-water. It was, therefore, found necessary to redredge the larger part of this channel, and to remove the material in scows. The work was commenced April 18, and continued until the available funds were exhausted, May 17; 2,000 feet of the channel were completed to a width of 45 feet, and about 700 feet to a width of 65 feet, the depth being from 5½ to 6½ feet at low-water. The material excavated was soft mud, and was deposited in Occoquan Bay. Six oak piles were driven on the easterly side of the channel to mark its direction. This channel would better retain its depth if it were located in the direction of the tidal currents. The original estimate was $18,000. The following appropriations have been made: $5,000 March 3, 1873; $5,000 June 23, 1874; $5,000 March 3, 1875.

Required to complete the work according to original estimate, $3,000.

For the dike, as proposed for the bar below Occoquan, $5,000 will be required.

Occoquan is in the collection-district of Alexandria.

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Money statement.

Amount available July 1, 1875	$5,493 92
Amount expended during fiscal year ending June 30, 1876	5,071 91
Amount available July 1, 1876	422 01
Amount (estimated) required for completion of existing project	8,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	8,000 00

G 4.

AQUIA CREEK, VIRGINIA.

At the date of the last report $2,000, appropriated March 3, 1875, were available for this work. The following bids were received and opened at 12 m., June 30, 1875:

Number.	Name and address.	Deposited on sides of channel.		Removed in scows.		Total.	Time of commencement.	Time of completion.
		Price per cubic yard.	Amount for 7,500 cubic yards.	Price per cubic yard.	Amount for 2,500 cubic yards.			
1	W. H. Beard, Brooklyn, N. Y	$0 20	$1,500	$0 25	$625	$2,125	Apr. 1, 1876	June 30, 1876
2	Thomas P. Morgan, Washington, D. C.	15	1,125	22	550	1,675	Sept. 1, 1875	Nov. 1, 1875
3	A. A. Dodge, Baltimore, Md	13	975	27	675	1,650	July 10, 1875	Sept. 10, 1875

Contract awarded to A. A. Dodge, Baltimore, Md.

Work was commenced August 4, 1875. The channel begun in 1874 was completed to the width of 40 feet and depth of 4 feet at low-water, and a portion further widened to 80 feet. The work was delayed by breakage of machinery and other causes, so that it was not completed until September 22, 1875.

The amount of material removed per day averaged 327 cubic yards for actual time worked. These operations have been conducted above the railroad bridge exclusively, and have been so directed as to attain the best results with the small appropriations and without deviating from the original plan. The character of the creek and the discussion of the improvement are fully given in the report of 1875. The total amount of appropriations was $5,500. The original estimate was $18,000. On account of delay in not completing the work at once this sum should be increased to $20,000. Every new contract for this work requires additional expenditure for towing the dredging-plant to and from the work, and as the *unfinished* cut fills more rapidly, much of the work has to be redredged. This would have been obviated by granting the amount of the original estimate in one appropriation. The work was so uncertain that Congress wisely concluded to order an experimental channel. The original estimate was $18,000. The following appropriations have been granted: $1,500 June 10, 1872; $2,000 March 3, 1873; $2,000 March 3, 1875.

The creek is in the collection-district of Alexandria.

Money statement.

Amount available July 1, 1875	$2,003 71
Amount expended during fiscal year ending June 30, 1876	2,003 71
Amount (estimated) required for completion of existing project	14,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	14,500 00

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G 5.

NOMINI CREEK, VIRGINIA.

The work was offered for contract under the act of March 3, 1875, appropriating $5,000. The following is an abstract of bids received and opened at 12 m., June 30, 1875:

Number.	Name and address.	Dredging.		Driving piles.		Time of commencement.	Time of completion.
		Per cubic yard.	Amount for 15,000 cubic yards.	Per linear foot.	Amount for 1,000 linear feet.		
1	J. H. Teemyer & Co., Baltimore, Md.	$0 30	$4,500 00	.....	No bid.....	Oct. 1, 1875	June 30, 1876
2	W. H. Beard, Brooklyn, N. Y	36	5,400 00	.....	No bid.....	April 1, 1875	June 30, 1876
3	Edgar M. Payn, Albany, N.Y	49½	7,462 50	$0 20	$200 00	Dec. 1, 1875	June 30, 1876
4	G. H. Ferris, Brooklyn, N. Y.	33	4,950 00	.....	No bid.....	Nov. 1, 1875	June 30, 1876
5	Thomas P. Morgan, Washington, D. C.	33	4,950 00	50	$500 00	Nov. 1, 1875	June 30, 1876

Contract for dredging awarded to J. H. Teemyer & Co., of Baltimore, Md.

The work to be done consisted in widening and deepening the existing channel near White Point and between Hickory and Ice-House Points, where the rapidity and direction of the currents made this process necessary for safe navigation, as well as the completion of the plan of improvement according to the original design.

Work was commenced October 6, 1875, but the dredging-machine used was not sufficiently strong, and frequently broke down, causing delays of from 1 to 6 days. The prevailing high winds also interfered materially with the progress of the work. Dredging was continued until November 30, when the boiler began to leak from the use of salt-water, so that it was found necessary to bring the dredge to Washington for repairs. Up to this date, 6,016 cubic yards of material had been excavated. This work has not yet been resumed. Oak piles have been driven to mark the channel.

The actual cost of conducting operations has been greater than was anticipated, on account of delays and increased contingent expenses due to the fact that the appropriations were granted in small sums. For this reason, as stated in my last report, $5,000 will be required to deepen and widen the natural channel and to build, if on re-examination it appears necessary, a short submarine dam.

The original estimate was $20,000. The following appropriations have been made: $10,000 March 3, 1873; $6,000 June 23, 1874; $5,000 March 3, 1875.

Nomini Creek is in the collection-district of Alexandria, which is also the nearest port of entry.

Since the suspension of dredging operations, small steamers have been regularly plying between the creek and Washington.

Money statement.

Amount available July 1, 1875	$4,997 67
Amount expended during fiscal year ending June 30, 1876	3,144 44
Amount available July 1, 1876, including $180.48 due on contracts	1,853 23
Amount (estimated) required for completion of existing project	6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	6,000 00

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G 6.

RAPPAHANNOCK RIVER, VIRGINIA.

At the date of the last report Mr. E. M. Payn was still engaged dredging a channel along the wharf-front at Fredericksburg. This work was completed July 28, 1875, giving a channel 9 feet deep and 50 feet wide. The excavated material was deposited behind the dikes. The completed channel is shown on map No. 1.

The amount offered for contract under the act of March 3, 1875, was $5,000. The following is an abstract of bids for this work opened June 30, 1875:

Number.	Name and address.	Price per cubic yd.	Amount for 15,000 cubic yards.	Time of commencement.	Time of completion.
1	E. M. Payn, Albany, N. Y	$0 49½	$7,481 25	Sept. 1, 1875	Dec. 31, 1875
2	G. H. Ferris, Brooklyn, N. Y	34⅓	5,175 00	Sept. 1, 1875	June 30, 1876
3	Thomas P. Morgan, Washington, D. C	38	5,700 00	Jan. 1, 1876	April 1, 1876

Contract awarded to Mr. G. H. Ferris, of Brooklyn, N. Y.

At the time fixed for commencing this work Mr. Ferris was engaged on river improvements elsewhere, which he had been unable to complete, and he was permitted to defer commencing until March 14, 1876. The work proposed was a channel 9 feet deep and 50 feet wide through that part of Fredericksburg Bar between the lower wharf and Deep Run. Owing to the lack of funds this was not completed. A heavy freshet occurred while the work was in progress, which filled in the upper end of the channel from 1 to 2 feet. Work was suspended May 8, 16,044 cubic yards having been excavated and deposited behind the lower dike, an average of 392 yards per day for actual time made. The material excavated was sand. This channel is shown on map No. 2. On May 6, 1876, an examination was made of the channel excavated by Mr. Payn along the wharves. It was found to have filled in generally about 2 feet, and at one point as much as 5 feet.

On May 28 a survey of Castle Ferry Bar was made. It is 9 miles below Fredericksburg, and is stated by steamboat captains to have the least water of any bar below Fredericksburg. The survey showed that 8½ feet can easily be carried over it at low-water, and its improvement at the present time seems unnecessary. The bar at Fredericksburg still remains the chief obstruction to navigation.

There has been no improvement in the trade of the river since 1874. (See report of Colonel Craighill to Chief of Engineers, 1875.) According to the original estimate, (Report of Chief of Engineers, 1875,) $44,000 will be required to improve the bars below the city, so as to give a depth of 10 feet at low-water. This depth is much greater than that which can be maintained on the Fredericksburg Bar by the annual expenditure of $7,500. Should Congress deem the trade of sufficient importance to justify the outlay, this sum should be expended each year to maintain a depth of from 8 to 9 feet at Fredericksburg.

The amounts appropriated for this river have been as follows: $15,000 March 3, 1871; $15,000 June 10, 1872; $15,000 March 3, 1873; $7,000 June 23, 1874; $5,000 March 3, 1875; $10,000 August, 1876.

The work is in the collection-district of Tappahannock.

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Money statement.

Amount available July 1, 1875	$13,437 57
Amount expended during fiscal year ending June 30, 1876	13,036 82
Amount available July 1, 1876	400 75
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	34,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	34,000 00

G 7.

ELIZABETH RIVER, VIRGINIA.

The act of March 3, 1875, appropriated $5,000 for this river, and the work was offered for contract, the following bids having been opened July 7, 1875:

Number.	Name and address.	Deposited in basin. Per cubic yard.	Deposited on marshes. Per cubic yard.	Time of commencement.	Time of completion.
1	E. M. Payn, Albany, N. Y.	$0 36	$0 44½	Dec. 31, 1875	June 30, 1876
2	H. E. Culpepper, Portsmouth, Va	29	35	July 10, 1875	Sept. 10, 1875

Contract awarded to H. E. Culpepper, Portsmouth, Va.

The work proposed was widening and deepening the river-channel between the Albemarle and Chesapeake Canal locks and Park's Gap to a depth of 7½ feet at low-water and a width of 60 feet. The work was commenced July 27, 1875, and completed as far as the funds would permit October 6, 1875. The material excavated was hard sand. It was deposited on the marshes, and in the river at localities where it would not interfere with navigation. The amount required to complete the work according to the estimate of last year was $8,500. The amount granted by Congress was $5,000. Whether the incidental contingent and other expenses due to delay in granting the full amount will increase the estimated cost of the work cannot be determined until the appropriation just made available has been exhausted.

The estimated cost of the improvement was $25,000. The appropriations by Congress have been: $15,000 March 3, 1873; $10,000 June 23, 1874; $5,000 March 3, 1875; $5,000 August, 1876. Additional sum asked, for reasons stated in last report, $3,500.

Elizabeth River is in the collection-district of Norfolk, Va.

The statistics of trade and tonnage appended to previous reports clearly establish the great importance of preserving the navigation of this river.

Money statement.

Amount available July 1, 1875	$4,726 40
Amount expended during fiscal year ending June 30, 1876	4,608 38
Amount available July 1, 1876	118 02
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	3,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	3,500 00

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G 8.

NANSEMOND RIVER, VIRGINIA.

The amount offered for contract under the act of March 3, 1875, was $5,000. The following is an abstract of the bids received, which were opened at 12 m. on July 7, 1875:

Number.	Name and address.	Deposited in deep water. Per cub. yard.	Thrown off lighters. Per cub. yard.	Deposited on marshes. Per cub. yard.	Deposited on wharves. Per cub. yard.	Removal of wreck	Time of commencement.	Time of completion.
1	H. E. Culpepper, Portsmouth, Va.	$0 22	$0 26	$0 32	$0 30	$400 00	Sept. 20, 1875	Nov. 20, 1875
2	J. H. Teemyer & Co., Baltimore, Md.*	28	No bid	No bid	No bid	450 00	Oct. 1, 1875	June 30, 1876
3	E. M. Payn, Albany, N. Y.	24½	43	50	No bid	No bid..	Sept. 1, 1875	Dec. 31, 1875

* Conditional on acceptance of bid for dredging.

Contract awarded to H. E. Culpepper, Portsmouth, Va.

The work proposed was a channel 60 feet wide and 7½ feet deep, at low-water, through the bar at Suffolk. The work was commenced October 20, 1875, the wreck being first removed and placed on the marsh on the opposite side of the river. The dredging was commenced October 25. Some of the material excavated was deposited on the marshes and wharves, but the larger part was dumped in a deep creek about one mile above Suffolk. On December 7, a second dredge was placed on the work, which was completed January 5, 1876.

The original estimate for improving the river was $30,000. Appropriations have been made as follows: $15,000 March 3, 1873; $10,000 June 23, 1874; $5,000 March 3, 1875; $5,000 August, 1876.

To complete the work according to the estimate of last year, $2,000 will be required. This sum should be expended in repairing the old dike near Western Branch Bar, which is in very bad condition.

Nansemond is in the collection-district of Norfolk, Va., which is also the nearest port of entry.

Money statement.

Amount available July 1, 1875	$6,921 52
Amount expended during fiscal year ending June 30, 1876	6,833 93
Amount available July 1, 1876	87 59
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	2,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	2,000 00

G 9.

ROANOKE RIVER, NORTH CAROLINA.

At the date of the last report the contractor for the dike at Indian Highland Bar was making preparations for the work. Before it could be commenced, however, the river rose, and work was not begun until

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October 15, 1875. It was continued with frequent suspensions from high-water and other causes until February 7, 1876, when the river again rose to such a height that operations were entirely suspended.

During the low-water of October 14 and 15, a measurement was made of the rocks partially removed at Weldon by Mr. Foote, under the direction of Colonel Craighill. The amount of rock-excavation was accurately ascertained, and payment was accordingly made for 63 cubic yards.

In my last report the difficulty of improving the bars in the Roanoke River between Weldon and Plymouth was fully stated. It is reported that the two dangerous bars above Norfleet's Landing, known as Rocky Bars, are not navigable when the water is below 3 feet, except by the Weldon steamboat, which draws but 1½ feet when half loaded. Bridger's Ferry is the head of navigation for all other boats plying on the Roanoke.

Inquiry has been made as to the head of navigation during the low-water season for several years. The following replies have been received:

1870, river not navigable above Hamilton from June 5 to September 12.
1871, river not navigable above Hamilton from July 18 to October 7.
1872, river not navigable above Hamilton from July 7 to October 30.
1873, river not navigable above Flag Run from July 27 to November 7.
1874, river not navigable above Flag Run from July 2 to December 4.
1875, river navigable the whole year to Norfleet's Landing.

Dangerous snags now exist at Indian Creek, Flag Run, Legget's Bar, and Norfleet's Landing, which interfere seriously with the navigation of the river, and should be removed.

If Congress should determine to continue this improvement, $45,000 should be appropriated for the next year, to be applied to the improvement of the bars next above Indian Highland, as indicated in the last annual report. If, however, it is the opinion that operations should be suspended, $3,000 will still be required for the removal of the snags above referred to.

The most serious obstacle to the practical operations of the improvement of the river (after the uncertain mutations of the sand-bars) is found in the unceasing oscillations of the water-surface. To determine the period and height of these movements, I have caused gauge-observations to be taken at Weldon, at Hamilton, 68 miles below, and at Plymouth, 122 miles below. I found great difficulty in securing accurate observers, but after carefully sifting the records I have concluded that the following table might be of value in case an improvement of the river is again ordered by Congress. It gives the height of the surface at Weldon and Hamilton for nearly every day from February 1, 1875, to June 30, 1876. It was found that the changes of the water-level at Plymouth were but little affected by the freshets in the river; the observations at this point were therefore discontinued, and none have been included in the table.

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Daily readings of the gauges at Weldon and Hamilton, on Roanoke River, North Carolina.

Day of month.	1875.																																			
	Feb.		March.		April.		May.		June.		July.		August.		Sept.		Oct.		Nov.		Dec.		1876. Jan.		Feb.		March.		April.		May.		June.	
	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.	Weldon.	Hamilton.
1	13.0	10.6	27.5	12.2	13.5	10.0	25.0	10.6	4.5	1.8	1.3	1.4	4.5	2.9	7.4	7.4	0.0	0.7	4.5	2.0	9.5	5.9	....	11.8	1.33	2.2	2.5	6.1	18.9	15.6	3.5	4.1	4.5	4.2
2	13.5	10.7	29.5	14.0	14.5	10.1	19.4	10.0	4.3	1.6	1.0	1.0	4.0	2.8	4.3	5.4	0.1	1.4	4.0	7.0	9.5	5.2	....	.....	1.25	2.2	2.33	5.2	16.75	15.5	3.25	4.1	2.8	4.3
3	12.5	10.5	21.0	14.1	16.5	10.0	16.2	9.1	3.0	1.5	1.0	1.0	8.5	3.0	2.1	4.7	0.3	2.1	2.5	6.0	9.0	4.0	....	11.7	1.2	2.1	2.0	4.6	13.2	15.4	2.7	2.7	1.8	3.4
4	9.5	10.0	30.0	17.0	14.0	9.6	10.9	8.9	3.0	1.4	3.5	2.9	13.0	8.0	0.2	3.3	0.0	1.7	2.0	4.0	8.5	3.0	....	11.0	1.33	2.0	1.9	4.0	11.5	15.4	3.0	4.2	1.3	2.5
5	9.0	9.9	33.0	17.5	14.5	9.9	6.3	8.2	2.8	1.4	3.0	2.7	16.2	12.0	0.0	2.3	1.0	1.0	3.5	2.0	11.5	4.6	....	9.2	2.1	2.4	1.8	3.6	12.1	15.0	5.5	5.3	2.3	2.5
6	7.5	9.6	35.2	18.5	15.0	10.0	5.5	7.7	2.5	0.4	2.5	2.6	16.0	12.0	0.0	1.0	1.7	0.2	4.5	3.0	13.5	11.2	5.33	8.1	2.1	3.0	1.5	3.25	11.2	14.5	4.1	6.0	4.3	2.3
7	6.5	7.9	30.0	18.0	16.3	10.0	6.0	7.1	3.0	0.5	2.5	2.4	17.0	12.2	0.0	1.8	2.5	—0.2	3.5	2.6	16.0	12.0	5.5	7.0	2.5	3.4	1.33	3.0	6.75	14.2	3.1	5.7	8.0	3.3
8	5.5	7.7	26.0	17.0	15.9	9.6	5.8	7.3	3.0	0.5	3.0	2.2	16.0	10.5	0.0	1.2	2.7	—0.4	7.5	2.4	21.0	12.4	4.33	5.9	5.33	4.0	1.1	2.7	7.4	13.4	2.75	4.2	7.0	5.6
9	4.5	6.0	22.0	16.5	14.0	9.3	5.5	6.8	6.2	0.6	6.0	3.5	16.5	11.1	0.2	0.7	3.4	—0.5	9.5	3.9	19.5	12.9	3.75	.....	7.4	6.4	1.0	2.5	5.9	....	2.4	3.5	3.6	8.4
10	3.5	4.0	22.0	16.5	12.8	9.0	5.1	6.0	6.0	2.2	7.5	6.0	16.4	12.4	1.0	0.2	2.0	.....	13.5	4.9	17.5	13.7	3.4	4.3	7.5	8.3	1.25	2.33	5.0	....	4.75	4.2	1.8	7.0
11	2.0	2.0	24.0	16.0	13.6	8.0	5.5	4.9	5.0	2.1	6.0	5.5	15.5	11.8	1.5	0.25	1.0	.....	13.0	7.4	15.5	13.9	3.3	3.7	6.2	9.0	1.4	2.4	4.0	....	16.4	10.5	1.0	4.8
12	2.0	1.6	19.0	13.9	13.0	7.9	5.0	4.1	4.5	0.6	6.0	5.6	15.0	11.1	3.0	0.2	1.0	.....	12.5	10.5	....	13.8	3.25	3.5	4.5	7.8	1.5	2.6	3.75	....	17.3	12.3	0.9	1.7
13	2.5	1.7	18.0	13.5	11.5	8.0	4.5	3.9	4.0	0.6	10.0	6.9	14.7	11.8	2.5	—0.2	0.6	.....	10.5	12.4	....	13.3	3.0	2.95	3.9	....	1.33	2.4	3.6	....	11.6	12.6	0.5	1.0
14	3.5	3.5	18.0	12.4	12.0	8.1	4.3	3.0	3.0	0.4	13.0	9.6	15.5	12.1	1.5	—0.5	0.4	.....	7.0	11.2	....	12.5	2.75	2.7	3.75	6.2	1.1	2.1	3.5	...	18.0	12.3	0.5	0.5
15	7.5	5.5	18.0	11.8	12.5	8.2	4.1	2.4	5.0	0.4	12.0	11.0	17.0	12.6	1.2	—0.4	0.4	.....	3.5	11.0	....	11.2	2.33	2.3	6.8	6.2	1.25	2.25	3.5	....	11.7	11.6	0.3	0.3
16	8.5	6.9	19.0	11.6	11.5	8.1	4.0	2.6	7.0	2.5	9.0	10.6	17.5	13.0	1.0	—0.1	1.5	.....	3.0	10.5	....	10.1	1.75	1.9	16.5	9.7	1.5	2.2	3.6	6.4	5.1	9.8	0.2	0.25
17	8.0	6.9	19.5	11.0	11.0	8.0	4.2	2.0	8.2	4.1	11.0	9.0	17.4	13.2	0.0	—0.2	3.0	.....	3.5	8.0	....	8.9	1.7	1.55	18.0	12.0	1.6	2.6	4.4	6.2	3.5	8.5	0.1	0.2
18	6.5	6.0	9.5	11.0	10.5	8.9	4.1	1.9	7.3	5.2	11.5	10.0	17.4	13.1	1.0	—0.25	2.4	.....	6.5	5.2	....	7.6	1.75	1.15	15.3	12.7	4.4	5.6	4.0	5.7	2.9	7.0	0.4	1.4
19	4.5	5.0	9.0	11.6	10.0	8.5	3.7	1.5	6.1	5.0	10.0	11.2	17.6	13.2	1.0	—0.2	1.7	.....	8.5	4.0	....	....	1.6	1.2	11.5	12.9	14.0	5.6	3.2	5.3	2.4	5.7	6.33	2.2
20	4.0	4.0	12.0	11.8	8.0	8.0	3.5	1.1	7.0	5.2	6.0	10.7	17.9	13.3	1.5	—0.33	1.0	.....	10.0	3.0	....	5.2	1.9	1.9	8.75	...	9.5	10.9	2.6	4.8	2.3	4.4	16.4	10.0
21	10.5	4.0	12.5	11.8	7.5	7.6	3.4	0.8	7.6	5.7	5.5	9.5	16.5	13.3	1.0	+0.6	0.7	.....	8.0	2.4	....	4.1	2.4	2.7	6.1	11.8	6.75	10.7	2.4	4.2	3.5	3.7	15.3	11.8
22	....	8.0	16.0	11.6	7.0	7.0	3.3	0.7	7.5	5.9	4.5	7.4	17.0	13.3	1.2	3.5	1.3	.....	7.2	1.9	....	3.0	3.25	3.8	5.1	11.6	9.5	9.1	2.25	3.4	4.3	4.4	6.4	10.5
23	....	8.9	18.0	11.7	6.0	6.2	3.0	0.7	6.9	6.4	4.0	5.7	17.5	13.6	1.0	4.1	2.5	.....	6.0	1.6	....	2.4	3.4	.....	7.2	11.4	9.25	8.2	2.33	3.2	5.25	5.7	3.75	9.5
24	....	9.4	17.3	11.8	6.0	5.6	3.0	0.5	6.0	5.9	4.5	4.9	17.0	13.9	1.2	3.1	3.0	.....	5.1	1.7	....	2.3	2.25	4.7	8.9	12.1	7.75	8.8	2.25	2.5	5.0	6.2	2.9	7.4
25	....	10.0	16.4	11.7	6.5	5.4	3.2	1.0	5.1	4.9	4.5	4.0	17.5	13.0	1.0	2.33	3.5	0.4	7.2	1.9	....	3.1	2.0	3.6	8.1	12.3	7.5	8.8	2.5	2.4	5.75	6.0	4.8	.....
26	....	10.5	14.1	10.0	6.0	5.0	15.0	3.0	4.4	4.0	5.5	4.2	17.3	13.0	1.0	1.2	2.5	0.45	8.0	2.1	....	....	2.5	3.2	5.9	12.5	14.33	9.6	4.0	3.2	4.3	6.4	4.2	4.1
27	....	10.9	13.6	10.0	7.0	4.6	11.0	7.7	4.0	3.8	5.5	4.1	16.5	13.2	1.1	0.5	2.0	0.5	8.9	2.5	....	3.0	2.75	3.6	2.25	12.9	21.25	10.4	4.33	3.5	2.6	5.3	3.8	2.8
28	27.0	11.3	14.5	11.6	7.5	5.8	8.2	6.7	1.5	2.6	6.0	3.4	16.0	11.8	0.9	0.2	1.5	0.5	9.5	3.0	....	3.2	2.0	3.6	3.5	9.8	23.1	10.8	3.75	4.8	2.0	3.7	3.6	1.7
29	....	....	14.0	11.6	9.5	7.9	6.4	4.8	2.0	2.6	6.5	2.7	14.0	11.3	0.8	0.0	1.5	0.6	11.0	3.8	....	4.8	1.75	3.2	3.0	7.6	19.0	11.6	3.0	4.7	2.3	2.7	3.4	1.0
30	....	....	13.5	11.4	20.0	8.9	5.0	3.3	1.5	1.8	6.0	2.4	12.1	9.5	0.4	0.25	1.0	0.65	10.5	5.5	....	9.5	1.5	2.8	.....	....	16.5	12.4	3.33	....	3.5	3.0	2.7	0.9
31	....	....	13.0	10.8	....	....	4.8	2.0	....	....	5.5	2.9	10.1	8.8	....	.....	3.5	1.0	....	....	....	11.4	1.33	2.5	.....	....	22.0	14.5	.....	....	3.7	3.5	.....	.....

The 0 of the gauge at Hamilton is 1 6-10 feet above the extreme low-water of July, 1876.

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The dates and amounts of appropriations for the river below Weldon have been as follows: March 3, 1871, $20,000; June 10, 1872, $10,000; March 3, 1873, $10,000; June 23, 1874, $5,000; total, $45,000.

The nearest collection-district is Edenton, N. C.

Amount of dike now completed, 986 linear feet.

Money statement.

Amount available July 1, 1875	$10,586 12
Amount expended during fiscal year ending June 30, 1876	5,303 49
Amount available July 1, 1876, including $236.88 due on contracts	5,282 63
Amount (estimated) required for completion of existing project	222,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	45,000 00

TABULAR STATEMENT OF DELAYS FROM BREAKAGE AND OTHER CAUSES ON SIX DIFFERENT IMPROVEMENTS.

Improvement.	Total working-days.	Actual time made.	Delays.		Depth of, cubic feet.	Average am't of excavation per day.		Causes of delay.
			Number days.	Per cent.		For working days.	For actual time.	
Aquia Creek	43	25¼	17¾	41	4	194	327	14¾ days for repairs.
Nomini Creek	48	27	21	44	9	123	233	Largely for repairs.
Occoquan River	66	52	14	21	5½	276	351	Freshet, low water, and repairs.
Rappahannock River	47	40 5-6	6 1-6	13	9	341	392	Freshets, &c.
Nansemond River	62	53½	8½	14	7½	*231	*257	Repairs.
Elizabeth River	61	47½	13½	22	7½	188	241	

* Two dredges employed for a part of the time. The amount is the average per dredge.

According to the above table, the delays in the dredging operations and the consequent loss of the contractor ranges from 13 to 44 per cent. The greatest delay occurs at points which are distant from shops where repairs can be promptly executed, or at localities exposed to the winds. The greatest are found necessary when the machinery is old. Another class of delays occur from want of foresight or judgment. A carefully-prepared record of the delays and their causes would supply valuable information to inexperienced contractors.

G 10.

EXAMINATION OF THE EAST BRANCH OF POTOMAC RIVER, FROM THE NAVY-YARD TO BLADENSBURG, DISTRICT OF COLUMBIA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., December 23, 1875.

GENERAL: In the act of Congress approved March 3, 1875, provision is made for an examination or survey of the East Branch of Potomac River from Bladensburg, Md., to the navy-yard, District of Columbia. This duty was assigned to me by your letter of March 22, 1875.

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In order to ascertain the intent of the above-mentioned provision, I addressed a letter to the Hon. Lloyd Lowndes, M. C., by whom I was referred to the president of the Chesapeake and Ohio Canal Company. I learned, on consultation with this gentleman, that the company of which he was president proposed to open a water-communication between the harbors of Washington and Baltimore, and that the improvement of the channel of the Eastern Branch was a part of this scheme.

To complete the canal to one of the navigable tributaries of Chesapeake Bay, the parties interested propose to form a joint-stock company and to obtain the aid of the State of Maryland to carry out the project. Two routes are practicable. The least expensive route will probably be found near an air-line from Bladensburgh to the Severn River, about eight miles above Annapolis. This line crosses the Patuxent about $1\frac{1}{2}$ miles below the confluence of the North Branch, and is $17\frac{1}{2}$ miles in length.

The other route will not be far distant from an air-line from Bladensburg to the Patapsco River, near the mouth of Deep Run, a distance of twenty-one miles. The distance from Deep Run to Baltimore by the channel of the Patapsco is very nearly 12 miles.

Two routes have been surveyed, both of which are near this air-line. That which seems to be the least expensive was examined by Mr. Isaac Trimble, in or about the year 1838. It is twenty-four miles in length, nearly. Following the Eastern Branch above Bladensburgh for ten miles, this route, after leaving the branch, passes over a ridge 155 feet above tide, then crossing the Patuxent 3 miles east of the air-line, it continues four miles farther to the North Branch of the Patuxent, passing over in this distance a ridge 135 feet above tide; then crossing the North Branch, $2\frac{1}{2}$ miles east of the air-line, it follows up a creek for 2 miles, and crossing over to Deep Run, it follows the run to the Patapsco River.

As a good map of the branch, made at the United States Coast Survey Office in 1862 and 1865, showed the condition of the river at those dates, I directed Assistant Engineer J. B. Duncklee to establish gauges to determine the character of the tides, and to sound the river, with the object of ascertaining whether any changes had taken place, as well as for the purpose of obtaining the information necessary for an estimate of the cost of improvement. This examination was made August 19 and 20, 1875.

The Eastern Branch is navigable (at low water) from its mouth to the navy-yard, a distance of $1\frac{3}{4}$ miles, by vessels drawing 14 feet. The ruling depth between the navy-yard and Anacostia bridge is 18 feet. The length of this bridge is 1,614 feet. The draw of this bridge is on the easterly side of the channel, has an opening of 33 feet, and will allow vessels drawing 12 feet to pass through.

Between Anacostia bridge and the Baltimore and Potomac Railroad bridge the ruling depth is 12 feet, and the greatest depth 22 feet. No obstruction to the desired class of navigation exists up to this point.

The Baltimore and Potomac Railroad crosses the river on a trestle-bridge. Its course is very oblique, 1,900 feet of it being near the west bank; its total length is 3,966 feet. This bridge has no draw, but the span at the channel is 100 feet, and is crossed by a Howe truss, the lower chord of which is $7\frac{8}{10}$ feet (in the clear) above low-water. For the uninterrupted navigation of the river the bridge should be provided with a draw. The channel keeps near the right or west bank; the flat on the left deepening from 2 feet at the upper bridge to 4 feet at the lower. The width of the river between banks is 1,340 feet.

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Between the Baltimore and Potomac Railroad bridge and Benning's bridge there are 2 shoals through which a channel should be dredged; one is about two-thirds of a mile above the railroad bridge, and the other is just below Benning's bridge. Benning's bridge is an ordinary trestle-bridge, the distance between the bents being 24 feet; the lower chord is $7\frac{7}{10}$ feet above low-water. This bridge should also be provided with a draw. Length of Benning's bridge is 690 feet.

Between these two bridges the river has an average width of 3,150 feet. The channel crosses by an easy curve from the left or east side to the right side, flowing between a grass marsh on the right and a flat on the left. The marsh covers nearly one-half of the area between the bridges. The flat, which is nearly as large, has a depth of from 1 to $2\frac{1}{2}$ feet at low-water.

For about 1 mile above Benning's bridge the river has an average width of 1,340 feet. In this area are two grass marshes, one next to the left bank having the dimensions 3,650 by 740 feet; the other, near the middle of the river, (and 300 feet above the bridge,) which is 750 feet long by 225 feet wide. The river contracts to 350 feet at 1 mile above the bridge, and is gradually reduced to 135 feet at Bladensburg, which is 4 miles from the bridge.

For a distance of about 1,000 feet above Benning's bridge a sufficient depth of water exists, but between this point and Bladensburg dredging will be required for almost the entire distance. Upon the flats and marshes which border the channel the dredged material can be deposited by shoveling it from the scows. The bed of the river is, in general, formed of hard sand, with an admixture of gravel near Bladensburg. At several localities sand is being excavated; the soundings at these points show a considerable increase in depth. This sand is sharp and clean, and is of a superior quality for making lime and cement mortars. It is extensively used for building-purposes in the city of Washington.

TIDE-OBSERVATIONS.

Tide-gauges were established at Benning's bridge and at Baltimore and Potomac Railroad bridge, but the observations did not extend over a period sufficiently long to permit the elimination of the effect of winds.

TIDES AT BLADENSBURG; OBSERVATIONS CONTINUED ONE MONTH.

Average low-water, 0.7 foot on the gauge.
Mean range of tide, 2.1 feet.
The lowest tide noted was 0.6.
The highest tide noted was 3.5.

There were frequent and heavy rains during the mouth, which caused small freshets in the river, so that the proper movement of the tide could not be determined. On several days the northwest wind was so strong as to keep back the tide almost entirely.

The observations at the Baltimore and Potomac Railroad bridge were taken but 9 days. The tides were affected by the wind and frequent rains. Average low-water (for 9 days) was found to be —0.1 on the gauge, the range being 3 feet. The lowest tide was —0.6. This gives at the Baltimore and Potomac Railroad bridge a range equal to that of the Potomac at the Long Bridge.

The following statement of distance is given:

	Miles.
Distance from Bladensburg to Benning's bridge	4.02
Distance from Benning's to Baltimore and Potomac Railroad bridge	1.47
Distance from Baltimore and Potomac Railroad bridge to navy-yard	1.42
Distance from navy-yard to mouth of Eastern Branch	1.75
Total distance from Bladensburg to mouth of Eastern Branch	8.66

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IMPROVEMENT.

The following estimate is based on the proposed excavation of a channel 100 feet wide, 8 feet deep, and 21,000 feet long, between Bladensburgh and the navy-yard. When the sides of the excavation assume their natural shape, the width will probably be reduced to 30 or 40 feet, and the depth to 7½ feet. Assuming that the shoaling in the branch will advance as rapidly as in the Potomac River below Easby's Point, the dredging operations will have to be repeated every 3 or 4 years, in order to maintain the requisite depth.

ESTIMATE FOR A CHANNEL 21,000 BY 100 BY 8 FEET.

382,430 cubic yards excavation, at 40 cents	$152,972
Contingencies, 10 per cent	15,297
Total	168,269

The present trade of the branch is insignificant, and its improvement has but little importance except in its relation to the proposed canal. In 1835 vessels carrying 100 hogsheads of tobacco, or about 60 tons, were able to load at Bladensburg. About the time railroads were introduced, from 1,500 to 2,000 hogsheads of tobacco were shipped annually to Alexandria, as I am informed by Mr. C. C. Hyatt. At the present time the channel is not practicable for barges except at high-water.

A map of the branch, from Bladensburg to its mouth, accompanies this report. The figures in red show some of the soundings taken by Mr. Duncklee, assistant engineer.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

G 11.

EXAMINATION OF THE HARBOR AT EDENTON, NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., December 14, 1875.

GENERAL: Provision is made in the act of Congress approved March 3, 1875, for a survey or examination of Edenton Harbor, N. C., which duty was assigned to me by your letter bearing date March 22, 1875.

As this harbor had been surveyed by officers of the United States Coast Survey, and an estimate, based on a subsequent examination, had been submitted by Colonel Craighill, a personal examination only was necessary to enable me to comply with the law of Congress.

Edenton Bay is in the northeast corner of Albemarle Sound. Its general form is triangular, being half a mile wide near the town, and about 1 mile southwardly, where the bay opens into the sound, it is 2½ miles wide. Chowan River enters the sound on the west of a broad pocoson swamp, separating it from the bay, while on the southwest, and 8 miles distant, and almost directly opposite the bay, the Roanoke pours its turbid waters into the sound.

Edenton, formerly the seat of colonial government in North Carolina,

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is now the county-seat of Chowan County, and has a population of 1,200 inhabitants. The small West Indian trade it once possessed has been absorbed by Norfolk and Wilmington. At the present time its trade is limited to Norfolk and Baltimore; steamers make weekly trips to Franklin, on the Seaboard and Roanoke Railroad, by way of Chowan and Blackwater Rivers. Shipments are also made to Norfolk and Baltimore by way of the Chesapeake and Albemarle Canal. Boats drawing 9 feet can safely navigate the Chowan and Blackwater Rivers, but in order to approach Edenton, or pass through the Albemarle and Chesapeake Canal, it would not be safe for them to draw more than 6½ feet.

The land in the vicinity of the bay is level and sandy, rising 8 to 12 feet above the sand, or sinking into swamps of cypress and black gum. It yields good average crops of corn, a small amount of cotton, fine pears and grapes, and some garden-truck for the Baltimore market. The natural growth consists of black gum, maple, ash, some oak and pine, and an undergrowth of reeds. Railroad-ties, shingles, and cypress-timber are shipped in small quantities. Herring and shad fisheries supply a large part of the annual shipment. The sandy beaches and the long gradual slope of the adjacent bottom afford facilities for drawing seines, which are sometimes from a mile to a mile and a half in length, and 18 feet deep. At times as many as 220,000 herrings are caught in one haul. Besides the fishermen, or boat's crew, there are 15 other men employed on shore, and 40 women and boys to trim, sort, and pack the herrings. The outfit and first year's expense of one seine amount to from $12,000 to $15,000.

The situation of Edenton Harbor is not favorable to the preservation of its depth. The feeble Chowan and the turbid Roanoke are confronted at the mouth of the harbor by the waters of Albemarle Sound, driven before the winds from the northeast round by east to the southeast. In periods of calm the Roanoke will transport its sediment into the harbor, and the movement will be increased by the winds from the southwest and southeast. The denudation of the headlands by the action of the waves further tends to reduce the depth along the entire coast of the sound. These causes are unceasing, and if they were not gradual the improvement of the harbors so situated would be impracticable.

The *gradual* deterioration under the influences above named affords sufficient reason to believe that a new and deeper channel can be made at a moderate cost to answer the present wants of navigation. A channel dredged on a line which is nearly on the prolongation of the main street of Edenton, having a length of 2,500 or 2,600 feet, and a depth of 9 feet, will retain its depth for many years. Although the steamers seldom draw more than 6½ or 7 feet, the variation in the level of the sound is one of several reasons which may be assigned for making a cut of this depth. The depth on the bar in ordinary low-water is 6¼ feet, and the 8½-foot curve of depth is reached about half a mile from the wharf. The oscillations of the water-surface sometimes reduce the depth from 1 to 2 feet. There are, however, no regular lunar tides in Albemarle Sound. A current, almost constant, tends to the east or down the sound, and the rise and fall of the water is influenced solely by the winds and the state of the river emptying into it. At the western end of the sound the water is depressed by northerly and westerly winds, and elevated by those from the south and east. The range of the oscillations varies from 1 to 2 feet, and under the influence of extraordinary storms may even double this quantity. Hence the importance of an ample depth in the new cut.

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In order to dredge the channel as above described and to deepen the approach to the wharves, the following estimate is submitted:

23,000 cubic yards of dredging, at 50 cents	$11,500 00
Superintendence and contingencies, 10 per cent	1,150 00
Total	12,650 00

A map of the harbor, showing the line of the proposed channel, accompanies this report.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

G 12.

EXAMINATION OF PASQUOTANK RIVER, FROM ALBEMARLE SOUND TO ELIZABETH CITY, NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., December 14, 1875.

GENERAL: In the act of Congress approved March 3, 1875, provision is made for the survey and examination of "Pasquotank River, North Carolina, from Albemarle Sound to Elizabeth City, N. C." This duty was assigned to me by your letter of March 22, 1875, and on the 10th of June I made a personal examination of the river.

Its general course is southwest, flowing between Camden and Pasquotank Counties, and emptying into Albemarle Sound near its northwestern extremity. From Elizabeth City to the sound the distance is 19 miles, and the channel is nearly straight. The river has the appearance of an arm of the sound, having for a distance of 2 miles an average width of one-half a mile, gradually widening toward the mouth, where it is 3½ miles wide.

Ten to 12 feet can be carried in a wide and nearly straight channel up to the town, where a depth of 30 feet can be obtained.

The river between the limits designated in the act is free from obstructions, and can be navigated by vessels of a much greater draught than are ever likely to enter it.

The Pasquotank derives its importance from being the outlet of the Dismal Swamp Canal, which enters the river about 12 miles above Elizabeth City. The river, therefore, has two channels of communication with Norfolk; one by the way of the Dismal Swamp Canal, and the other by way of the Albemarle and Chesapeake Canal. The first canal has a depth of 4 feet, the latter of 6½ feet.

The population of Elizabeth City is about 3,000. As no improvement is required, no estimate is submitted. A map of the river accompanies this report.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

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G 13.

EXAMINATION OF PERQUIMANS RIVER, FROM ITS MOUTH TO THE TOWN OF HERTFORD, NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., December 14, 1875.

GENERAL: The act of Congress approved March 23, 1875, contains a provision for the survey of the Perquimans River from its mouth to the town of Hertford, N. C., and this duty was assigned to me by your letter under date of March 22, 1875.

The Coast Survey chart exhibited no special obstruction to navigation, and it became necessary to visit the river to ascertain whether any obstruction existed. With this object, on the 12th of June last, I visited Hertford in a small steamer.

The Perquimans River is about 11½ miles long from Hertford to entrance into Albemarle Sound, flows southeastwardly, and has a general width of 1½ miles. Nine feet water can be carried up to the town, where the only obstruction to navigation is found. Here several logs and stumps have accumulated a small quantity of sand, and impede the approach of steamboats during low-water. The range of the water under the influence of the winds is about 2 feet, and the oscillations are such as have been described in my report on Edenton Harbor.

The town of Hertford has about 500 inhabitants. Steamers from Norfolk touch at the town on their way to Edenton and Roanoke River. Portions of the land of Perquimans County have been well ditched and drained, and produce fine crops of wheat, corn, oats, and sweet-potatoes. A floating bridge just above the landing gives access to the large saw-mill which supplies the town and neighborhood and also 600,000 feet of lumber for shipment. The timber is floated down the river, which is navigable for several miles above the bridge. Mr. Lindsey, a citizen of Hertford, informs me that a large amount of timber is shipped in the log, and that the usual yearly exports amount to 25,000 bushels of corn and 1,500 bales of cotton.

For removing the logs and débris which has accumulated about them, I should estimate the cost—if done at the same time as the work required for Edenton Harbor—at $2,000.

A map, showing the position of the logs and stumps, accompanies this report.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

G 14.

EXAMINATION OF PAMPLICO RIVER, FROM ITS MOUTH TO THE TOWN OF WASHINGTON, NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., December 14, 1875.

GENERAL: The act of Congress approved March 3, 1875, provides for the survey or examination of Pamplico River, North Carolina, which duty was assigned to me by your letter of March 22, 1875.

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The river has been carefully surveyed by officers of the United States Coast Survey and of the Corps of Engineers. A personal examination was therefore made with a view of determining what changes had taken place, and whether any modification of the proposed improvement was required.

Pamplico River lies in Beaufort County, North Carolina. Its course is southwestwardly, nearly straight, and it empties into the southwestern end of Pamplico Sound, about 37 miles from Washington, N. C. The ordinary lunar tides are about 12 inches, but under the influence of the winds the range may be 2 or more feet.

An examination of the river was made under the orders of Colonel Craighill, and in his report, dated December 31, 1872, an estimate was submitted for removing the artificial obstructions placed in the river during the war, for dredging the bar below the town, and for the construction of a dike. These obstructions are encountered about 6 miles below the town of Washington, and nearly opposite Hill's Point. They consist of 4 rows of piles, driven in pairs, so that the second row is about 10 feet from the first, each pile being driven so as to divide the space of the preceding row. At an interval of 150 yards the second pairs are driven in the same manner. These piles were cut off at 3 feet below low-water, and present a formidable obstruction to navigation. A channel, 100 feet wide, has been opened through them, and is marked by buoys.

This narrow pass is not only dangerous at night and in foggy weather, but offers a serious obstacle to vessels beating up the river at any time. The bar commences nearly opposite the lower wharf. The worst point occurs about half a mile from the wharf. Five feet depth is found here at low-water, and under the influence of the winds the depth is much less. On such occasions boats are compelled to load below the bar. From this point the water deepens very gradually; in fact the bar may be said, with short intervals, to extend 7,400 feet, the depth in this distance ranging from 6½ to 7 feet, the deeper intervals being 8 feet. The sudden expansion of the river, the meeting of the tidal and fluvial currents, and a current from a small bay and creek on the north side, combine to form this bar. The expansion may be reduced, and the effect of the creek and bay neutralized by a dike. No structure of the sort was recommended by Colonel Craighill, and I have omitted it from my estimate on account of the following considerations: A short dike of 2,100 feet in length, near the northern shore, would but partially modify the forces which form the bar, and, on the other hand, a long (7,400) dike near the channel would transfer the bar lower down, and would itself prove an obstruction, unless marked by a beacon. Without further examination the position and effect of a dike cannot be definitely determined. Its construction, therefore, may be deferred until the effect of the dredging and of the removal of the obstructions can be observed.

The town of Washington, at the head of navigation on the Pamplico River, has a population of 2,000. The steamers which ply between the points of the sound and Norfolk and Baltimore cannot proceed above Washington, but a small steamer ascends as far as Greenville at low-water, and at high-water as far as Tarborough, 25 miles from Washington. A branch railroad connects Tarborough with the Wilmington and Weldon Railroad.

Twice during the war Washington was nearly destroyed by fire, but it is now slowly recovering the population and trade which it had in 1861. A large and flourishing timber trade at that time was carried on

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between the town and northern ports, the lumber being composed chiefly of pitch-pine.

Mr. Elliot estimated the tonnage at 1,125 tons, which he regarded as less than the actual amount. Beaufort County, which is chiefly tributary to Washington and the trade of the Pamplico River, has a population of 13,011. According to the last census, the value of the farm-products is $496,161. The land-products, in bushels, are as follows: Wheat, 1,987; corn, 179,994; oats, 3,674; Irish potatoes, 3,893; sweet-potatoes, 102,625; and 1,987 bales of cotton, 3,245 pounds of tobacco, and 59,206 pounds of rice.

APPROXIMATE ESTIMATE.

33,000 cubic yards of dredging, at 50 cents	$16,500 00
1,500 piles, at $6 each	9,000 00
Contingencies, 10 per cent	2,550 00
Total	28,050 00

This amount should be granted in one appropriation, in order that the work may be economically executed.

A map, showing the Pamplico River and the harbor of Washington, accompanies this report.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

G 15.

EXAMINATION OF NEUSE RIVER FROM ITS MOUTH TO GOLDSBOROUGH, NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., December 14, 1875.

GENERAL: A survey or examination of Neuse River, North Carolina, was ordered in the act of Congress approved March 3, 1875. This duty was assigned to me by your letter of March 22, 1875, in accordance with which I have now the honor to submit the following report:

My duty was simplified by existing reports of former surveys, and by charts of the river, prepared by the United States Coast Survey. The report of Colonel Craighill, dated December 30, 1871, (see Report of the Chief of Engineers, 1872,) contains a specific estimate and a full description of the river and the nature of the obstructions. This report covers the navigable portion between Goldsborough and the mouth of the river, a distance of 137 miles. Of the part of the river below New Berne, forming what may be considered an estuary of Pamplico Sound, a chart, dated 1874, has been published, which is based on surveys made in 1862 under Prof. A. D. Bache, and in 1872 under Professor Peirce. With the ample information contained in these reports and charts, a personal examination was all that seemed necessary for the performance of the duty assigned to me.

Leaving Norfolk June 17, I proceeded by way of the Albemarle and Chesapeake Canal, and through Carrituck, Croatan, and Pamplico Sounds, to New Berne, by the regular line of steamers.

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GENERAL DESCRIPTION.

The following general description of the features of the river is based on the information then obtained and on the sources already mentioned. The Neuse River rises in Person and Orange Counties, flows southwest through the counties of Wake, Johnston, Wayne, Lenoir, Craven, and Pamplico, and empties into Pamplico Sound. It is cut off from the drainage of the western highlands by the Dan and Haw Rivers. Its entire drainage-area is estimated at 5,000 square miles, its length 325 miles, and its total descent to tide 340 feet. At Goldsborough, 137 miles from the mouth, the elevation of the land is 102 feet above mean tide. The descent to New Berne, 97½ miles, is not known, but must be small. Between its source and Goldsborough, it has cut its way through Laurentian, Huronian, Triassic, and Cretaceous strata; from thence its course is through Cretaceous, Miocene, Eocene, and Quaternary formations.

At Broadway Landing, near Fort Barnwell, Huronic slate and shell conglomerate appear near the water-surface. About 30 miles above New Berne is found a valuable kind of stone marl which underlies that city and the adjacent country, in some localities showing itself at the surface, at others sinking 40 or 50 feet below it. This marl is generally bluish in color, and consists of shells so strongly cemented with silica that small millstones have been made of it. When removed from the quarries it is usually so plastic that it can be readily cut in any shape or size for building-stones, which subsequently harden under exposure. It is used about New Berne for building purposes, and good specimens may be seen in the coping of the wall around the cemetery. From the above description, it is evident that this marl possesses remarkable qualities as a building-material, and that its general use is limited only by the extent of its outcrop. Another variety of the marl is of a buff color.

The soil is sandy, and inferior in productiveness to the Hyde County land.

Between Goldsborough and New Berne the height of the banks varies from 3 to 20 feet; in fact, below Contentnea Creek the banks and adjacent bottoms are but a few inches above low-water. The floods, which reach an altitude of 12 feet, cover a wide area, and leave behind them sloughs which mark former cut-offs, or the old bed of the stream. The river is very tortuous, cut-offs are formed, and the resulting bends offer serious obstructions to navigation. Before any plan can be proposed for their correction, a more careful survey will be required. The bridge of the Atlantic and North Carolina Railroad (connecting Goldsborough, New Berne, and Beaufort) crosses the Neuse about 3 miles below Kinston. As this bridge is but 17 feet above low-water, it is impassable by steamboats, and the span is so narrow that it can be passed only with difficulty by rafts and barges. The condition of the river and the works constructed by State authority in 1836 and 1837 are described in the report submitted by Colonel Craighill. The wing-dams are said to be in good condition, but the coffer-dam and foundation of an unfinished lock at the mouth of Contentnea Creek obstruct the navigation. Between Goldsborough and Contentnea a large number of snags, logs, and leaning trees make the navigation difficult, but the most formidable obstructions consist of cribs filled with stone, sunken vessels, and piles, which were placed in the channel during the war. As the removal of these obstructions will tend to modify the form of the channel and bars, it would not be advisable to attempt any other kind of improvement until these changes have taken place. The pres-

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ent low-water depth above Kinston is about 3 feet, and 4 feet water (or 5) can be carried to New Berne at the same stage. The railroad-bridge makes the landing near Kinston the head of navigation, but, with a draw in the bridge, steamboats at average stages of the river can reach Goldsborough. A small steamboat, drawing about 18 inches of water, now plies on the river above New Berne.

TRADE STATISTICS.

The statistics of trade are given on pages 737 and 741 of the report already referred to, but the following additional and later statement has been furnished to me by Mr. J. J. Roberson:

Cotton	25,000	bales.
Shingles	10,000,000	
Oak staves	200,000	
Naval stores	50,000	pounds.
Lumber	10,000,000	feet.
Corn	800,000	bushels.
Eggs	5,000	barrels.
Potatoes, (sweet and Irish)	60,000	bushels.
Fish	10,000	barrels.
Oysters and clams	15,000	barrels.
Vegetables	5,000	barrels.
Hides	60,000	pounds.

Besides a large quantity of furs, bees'-wax, tallow, train-oil, wheat, field-peas, ground-peas, (pea-nuts,) railroad-ties, light wood for manufacturing pine-oil, watermelons, apples, and various other fruit. Several cargoes of sugar-shooks and heading for the Cuban market were also shipped.

During a greater part of the year there were 6 steamers plying between this and the ports of New York, Norfolk, and Baltimore, besides one small steamer from this port to Kinston, on the Neuse.

With regard to the value of importations at this port during the past year, I am at present unable to give any information, but would judge that they would amount to at least $2,000,000 for the year.

The distances to prominent points from Goldsborough to New Berne, and the general nature of the obstructions, are given in the following table:

Location.	Intermediate distances.	Total distance.	Width of river.	Remarks.
	Miles.	*Miles.*	*Feet.*	
Goldsborough	.....	.....	80	Population, 1,500.
Whitehall	22	22	75	Sharp bend; unstable regimen.
Let-alones	4	26	215	Bends; natural cut-offs; unstable.
Kinston	20 4-5	46 4-5	.....	Near head of navigation by steamboats; population, 1,000.
Railroad bridge	3	49 4-5	280	No draw; 17.6 feet span, and 17 feet above low-water.
Southwest Blockade	5 1-5	54	250	Cribs filled with stones.
Contentnea Creek	12	66	300	Coffer-dam of old lock.
Pitch-Kettle Shoal*	10 3-5	76 3-5	.....	State improvement; wing-dams; 1856-'57.
Hog-Island Blockade	18	94 3-5	2,240	Sunken cribs and schooner.
New Berne	3	97 3-5	5,280	Population, 3,000.

* Also called Bachelor Creek.

PROPOSED IMPROVEMENT AND ESTIMATE OF COST.

I have thought it advisable, while adopting the plan submitted by Colonel Craighill, to consider the improvement of the river as separated

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into two divisions, and to present a separate estimate for each. The aggregate cost remains unaltered.

The upper division, from Goldsborough to New Berne, a distance of 97 miles, is fluvial, except for a short distance near the lower end. The second division, extending from New Berne to Pamplico Sound, a distance of 40 miles, is tidal and fluvial, having a lunar tide of from 4 to 8 inches, and ranging, under the influence of the wind, from 1 to 5 feet. In the upper division, the navigation is confined to barges and light-draught steamers; the lower division affords a commodious channel for any vessels able to pass the bar of Ocracoke Inlet, which has a low-water depth of 9 feet, according to report.

In both divisions the character of the proposed improvement is nearly the same, being confined for the most part to the removal of natural and artificial obstructions of snags, trees, cribs, and sunken vessels. The improvement of the two divisions can be executed contemporaneously or successively, as Congress may direct.

ESTIMATE OF DIVISION 1.

Special obstructions requiring removal, snags, logs, leaning trees, partial regulation of cut-offs	$35,000 00
Southwest Blockade, 7 miles below Kinston, 5 cribs filled with stone	465 00
Piles of old bridge and coffer-dam at Contentnea Creek	1,200 00
Hog Island, or Bachelor Creek Blockade. There are 3 channels at this point of the river, all of which are blockaded by barges, cribs filled with stone, and sunken schooners. The channels are named as follows, commencing at the southwest side of the river: Bachelor Creek Channel, Main Channel, between Hog's Island and Green Island, and the Singfield Channel. The Main Channel only requires improvement at the present time. For a minute description of these obstructions, I would refer to page 737 of Report of Chief of Engineers, 1872. Cost of removing obstructions in Main Channel	900 00
	37,565 00
Contingencies, 15 per cent	5,634 00
Total	43,199 00

SECOND DIVISION.

From New Berne to the mouth of the river the distance is 40 miles. The Trent River enters on the south side of the city, having a width of 1,000 feet; on the east side the river is about 1 mile wide; at the obstructions the width is 1 mile; at the mouth, in Pamplico Sound, it is 5½ miles. Only 2 obstructions are found in this division; one, a small bar which may be easily avoided; the other, consisting chiefly of sunken vessels, about 3 miles below the city and opposite Old Fort Point. A minute description of the obstructions will be found on page 738 of Chief of Engineer's Report of 1872. A channel, marked by the mast of a sunken vessel, has been opened, but in foggy and dark weather sailing-vessels get lodged on one of the sunken hulls. By removing one brig and one or two schooners, and some of the "Yankee-catchers," a channel 1,000 feet wide and 10 feet deep can be obtained. Five of the sunken vessels will still be left, and, to prevent danger, it will be necessary to mark the channel-end with a beacon. The accompanying sketch, showing a mast supported by brace-piles and bolted and branded with iron, will answer for the purpose of definitely marking the dangerous part of the channel.

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ESTIMATE OF DIVISION II.

Fort Point Blockade	$5,600 00
Removing Yankee-catcher	100 00
Beacon at blockade	1,000 00
	6,700 00
Contingencies, 15 per cent	1,005 00
Total	7,705 00

Aggregate estimate of the cost of the two divisions:

Division I	$43,199 00
Division II	7,705 00
Total cost	50,904 00

or an aggregate of $51,000.

Three tracings accompany this report, showing the general course of the river to New Berne, the blockades, and the lower river.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

G 16.

EXAMINATION OF CATAWBA RIVER, FROM SOUTH CAROLINA LINE TO OLD FORT, NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., December 23, 1875.

GENERAL: In the act of appropriation approved March 3, 1875, provision is made for an examination or survey of Catawba River, from South Carolina line to Old Fort, N. C. This duty was assigned to me by your letter of March 22, 1875, and I have now the honor to report the result of a personal examination made in September, 1875.

Proceeding by way of Lynchburg and Danville to Salisbury, N. C., I took the Western North Carolina Railroad, which follows the valley of the Catawba to Old Fort, its present terminus. This road has been graded beyond that point and along the valley of the French Broad, as far as the East Tennessee and Virginia Railroad; the viaducts and tunnels were nearly completed when the work was suspended for want of funds. This portion of the road (west of Old Fort) passes through a region which is regarded as the most salubrious and picturesque in the States east of the Mississippi. When the graded portion of the road is completed, New Orleans will be connected by rail with Beaufort, N. C., and several important through lines.

GENERAL DESCRIPTION.

The sources of the Catawba River are to be found along the foot of the Blue Ridge, in McDowell County, North Carolina. One of its little tributaries rises at the base of Mount Mitchell, which dominates the subjacent valley from an altitude of 6,582 feet. The river descends to the level of 1,300 feet above tide by a series of beautiful cascades, and flows

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thence through the counties of McDowell and Burke, and forms the boundary-line of seven others, viz, Caldwell, Alexander, Iredell, and Mecklenburgh, lying north or east of it, and Catawba, Lincoln, and Gaston, to the south or west. After passing the State line the Catawba becomes the Wateree, then the Santee, and terminates its tortuous course in the Atlantic between Georgetown and Charleston, S. C.

The present report is limited by the act of appropriation to the part of the river lying between Old Fort and the South Carolina line.

At Old Fort the river has reached the base of the so-called Piedmont region, at an altitude of 1,274 feet above mean tide. From thence its course is north of west to the great bend between Morganton and Statesville, where, 75 miles east of Old Fort, it turns southward, and continues its course to the State line, a distance of 75 miles farther, or 145 miles in all.

From Old Fort to the great bend the fall, according to Professor Kerr, is a little over 500 feet, and from there to the State line 300 feet, or a total of 800 feet. According to the levels of Hamilton Fulton, the difference of elevation between Old Fort and the State line is 789 feet.

Besides the great bend already mentioned, another and smaller bend occurs between Rozzel's Ferry and Abernethy's Island. This bend has the shape of the letter A, and is 7½ miles around and 1½ across. Throughout the bend the river is characterized by deep natural pools or reaches, extending along the convex sides of the bends. The greatest low-water depth occurs at these places, and is 18 feet at Tuckasegee Shoals. Fulton's profile represents the depth of water on the shoals and bar as greater than might be expected, on account of the large average fall per mile. Four of these shoals have but 6 inches of depth at low-water, several not more than 3. The greatest descent is at Lookout Shoal, where the fall is 3.51 feet in 111 feet, or at the rate of 167 feet per mile. At other points the rate per mile is 82 feet, 78 feet, 64 feet; two rapids have 40 feet each, others have 34 feet, 33 feet, and two have 30 feet; the rest vary from 6 to 26 feet per mile.

Hamilton Fulton, an intelligent engineer, made, in 1824, under the authority of the State of North Carolina, a survey from Moore's Shoals, 10 miles below Morgantown, to the State line. Unfortunately Mr. Fulton's report is not to be found in the archives of the capitol at Raleigh. A portion of his map and profile are, however, extant, and to these data I am indebted for the material which has been condensed in the following tabular statement. Mr. Fulton's map—so much of it as can now be found—extends from Sherrill's Ford to the State line, a distance of 48¾ miles; the profile extends from Moore's Shoal to the State line, a distance of 92½ miles. Following the order of the columns, the information is condensed under the heads of "Names of localities at time of survey;" "Distance from Moore's Shoals;" "Length of each shoal or reach;" "Difference of level referred to Moore's Shoals;" under the head of "Descent of the river" are given the total fall and average fall per mile of each pool and shoal, and the maximum fall in the shortest distance observed, and the corresponding rate per mile; the next column gives the ranges of low-water depths between named points; the tenth column gives the height above mean tide, computed from railroad surveys; and under the column of "Remarks" are stated the dimensions of the mill-wheels existing at time of the survey. The names belong to the period of survey, (about 1824.)

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Table of distances and levels.

Locality.	Distance from Moore's Shoals.	Length of each shoal and pool in succession.	Difference of level from Moore's Shoals.	Descent of the river. Fall of each pool and shoal. Total.	Fall of each pool and shoal. Average per mile.	Maximum fall in a given distance. Feet-fall and distance.	Maximum fall in a given distance. Corresponding rate per mile.	Depth of water.	Calculated height above tide-water.	Remarks.
	Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	
Top of Moore's Shoals	.0	.....	.0	.....	.....	.....	.....	.....	908.50	
Top of Devil's Shoals	.66	.66	1.94	1.94	2.94	.....	.....	1.7 to 3.0	906.56	
Lock	.98	.32	6.58 / 9.35	4.64	14.50	4.20 in 1,320 feet	16.80	1.3 to 3.3	901.92 / 899.15	
Lock	1.40	.42	11.42 / 13.42	2.07	4.93	.....	.....	0.8 to 4.6	897.08 / 895.08	
Bottom of Devil's Shoals	1.67	.27	15.72	2.30	8.52	1.66 in 898 feet	9.17	0.8 to 2.5	892.78	
Series of pools and shoals	3.49	1.82	24.60	8.88	4.88	0.9 in 845 feet	56.2	1.0 to 4.5	883.90	
Natural pool	4.88	1.39	25.86	1.26	.90	.....	.....	2.0 to 5.0	882.64	
Horse-Ford Shoals	7.79	2.91	57.29	31.43	10.80	0.4 in 53 feet	40.00	0.5 to 5.0	851.21	
Natural pool	8.18	0.39	58.15	0.86	2.20	.....	.....	2.2 to 5.2	850.35	
Gunpowder Shoals	8.45	0.27	59.50	1.35	5.00	0.4 in 53 feet	46.00	2.0 to 5.0	849.00	
Natural pool	9.20	0.75	59.88	0.38	0.50	.....	.....	1.4 to 8.0	848.62	
Fall at Upper Little River	9.87	0.67	62.73	2.85	4.25	1.32 in 1,400 feet	4.98	1.6 to 4.5	845.77	
Natural pool, with one fall	11.23	1.36	64.70	1.97	1.45	0.75 in 132 feet	30.00	2.0 to 6.2	843.80	
Falls below Crosses' Rock	11.67	0.44	68.46	3.76	8.54	2.61 in 1,003 feet	13.74	1.8 to 5.5	840.04	
Falls	12.51	0.84	71.30	2.84	3.38	0.89 in 369.6 feet	12.71	1.8 to 6.5	837.20	
Natural pool	14.91	2.40	74.65	3.35	1.39	0.3 in 196.7 feet	12.50	1.8 to 10.0	833.85	
Falls Middle Little River	15.77	0.86	77.50	2.85	3.31	0.6 in 163.7 feet	19.35	1.7 to 6.0	831.00	
Pool top of Oxford Shoals	16.52	0.75	77.74	0.24	0.32	.....	.....	2.0 to 5.3	830.76	
Bottom of Great Falls	17.54	1.02	92.56	14.82	14.53	14.82 in 1.02 miles	14.53	0.5 to 8.0	815.94	
Near Canoe Landing	19.41	1.87	101.50	8.94	4.78	0.7 in 111 feet	33.33	1.4 to 8.0	807.00	
Natural pool	20.86	1.45	104.73	3.23	2.23	.....	.....	2.0 to 9.0	803.77	
Falls at Lower Little River, and below	21.68	0.82	108.05	3.36	4.05	1.18 in 1,003 feet	6.21	1.6 to 8.0	800.45	
Top of falls, lower end of Three-Cornered Island.	22.16	0.48	108.80	0.75	1.56	.....	.....	4.0 to ——	799.70	
Upper end of Druin's Island	22.84	0.68	117.75	8.95	13.16	2.05 in 132 feet	82.00	0.6 to 5.0	790.75	
Top of Lookout Shoals, Cowan's Island	24.21	1.37	119.41	1.66	1.21	.....	.....	2.0 to 9.5	789.09	
Bottom of Lookout Shoals	27.51	3.30	173.66	54.25	16.44	3.51 in 111 feet	167.14	0.5 to 4.0	734.84	Sherrill's Mill at 25.18 miles. Wheel 12½ feet in diameter.
Pool	28.83	1.32	182.30	8.64	6.54	.....	.....	1.9 to 7.0	726.20	
Series of shoals	31.01	2.18	192.01	9.71	4.45	2.05 in 317 feet	34.17	1.2 to 7.5	716.49	

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Table of distances and levels—Continued.

Locality.	Distance from Moore's Shoals.	Length of each shoal and pool in succession.	Difference of level from Moore's Shoals.	Descent of the river.				Depth of water.	Calculated height above tide-water.	Remarks.
				Fall of each pool and shoal.		Maximum fall in a given distance.				
				Total.	Average per mile.	Feet-fall and distance.	Corresponding rate per mile.			
	Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	
Natural pool	32.525	51.515	193.20	1.19	0.78			1.5 to 14.5	715.30	
Shoal near Lewis's Fish-Trap	33.73	1.20	195.95	2.75	2.28	0.25 in 132 feet...	10.00	1.0 to 4.2	712.55	
Natural pool	36.95	3.22	197.20	1.25	0.39			2.0 to 15.5	711.30	
Buffalo Shoals	37.61	0.66	208.61	11.41	17.29	1.61 in 317 feet...	26.83	0.8 to 5.0	699.89	
Natural pool	38.76	1.15	212.84	4.23	3.68			1.0 to 8.7	695.66	
Fall at Small Island	38.81	0.05	216.77	3.93	78.60	3.93 in 264 feet ..	78.60	2.5 (av'ge)	691.73	
Pool	39.58	0.77	217.86	1.09	1.42			0.5 to 5.5	690.64	
Shoals and falls from Crawford Island to Platt Island.	41.27	1.69	241.30	23.44	13.86	1.83 in 150 feet...	64.42	0.5 to 9.5	667.20	
Lower end island below Sherrill's Ford	43.15	1.88	254.43	13.13	6.98			0.3 to 7.0	654.07	
Series of shoals	44.41	1.26	259.65	5.22	4.14	1.05 in 184.4 feet.	30.00	1.5 to 9.0	648.85	
Pool	45.32	0.91	260.72	1.07	1.18			1.5 to 7.0	647.78	
Shoal near Moses Sherrill's	45.77	0.45	262.15	1.43	3.18	0.55 in 950 feet...	3.06	2.0 to 7.0	646.35	
Natural pool	47.94	2.17	264.00	1.85	0.85			2.0 to 11.8	644.50	
Fall	47.99	0.05	265.26	1.26	25.20	1.26 in 264 feet...	25.20	1.0 to 1.8	643.24	
Natural pool	49.45	1.46	267.10	1.84	1.26			1.5 to 11.0	641.40	
Fall at Jackson's Fish-Trap	49.57	0.12	269.25	2.15	17.92	2.15 in 634 feet ..	17.92	1.3 to 5.0	639.25	
Natural pool	52.42	2.85	269.70	0.45	0.16			3.0 to 8.0	638.80	
Mountain Creek Shoal	54.52	2.10	274.79	5.09	2.42	.06 in 264 feet...	12.00	2.0 to 3.0	633.71	
Natural pool	56.01	2.49	276.60	1.81	1.21			2.8 to 10.0	631.90	Mill at Beattie's Ford; shoals at 56.61 miles; wheel 9 feet in diameter.
Beattie's Ford Shoals	58.39	2.38	289.60	13.00	5.46	1.2 in 158 feet...	40.00	1.0 to 5.5	618.90	
Natural pool below Cathey's Island	60.37	1.98	291.65	2.05	1.03			3.0 to 11.8	616.85	Henry Connor's mill at 62.03 miles; wheel 13.20 feet in diameter.
Cowan's Ford Shoals	64.54	4.17	318.90	27.25	6.51	0.8 in 211 feet...	20.00	0.5 to 8.0	589.60	
Natural pool	65.65	1.11	319.10	0.20	0.18			6.0 to 19.0	589.40	
Fall's at Tool's Ford	65.93	0.28	320.20	1.10	3.93			1.2 to 3.4	588.30	
Natural pool	68.21	2.28	322.80	2.60	1.14			4.0 to 15.0	585.70	
Small fall	68.27	0.06	323.35	0.55	9.17			2.0 to 3.0	585.15	
Natural pool	69.44	1.17	324.83	1.48	1.26			2.0 to 15.0	583.67	
Series of falls near Hoslop's Ford	72.39	1.85	329.69	4.86	2.62	1.29 in 686 feet...	9.92	1.5 to 9.8	578.81	
Natural pool	74.36	2.07	331.78	2.09	0.66			3.0 to 17.9	576.72	

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Abernathy's Fall	74.48	0.29	338.60	2.03	17.86	2.04 in 479 feet	22.66	1.5 to 5.0	572.88	
Natural pool	75.60	1.12	336.45	1.00	0.71			2.5 to 10.0	572.05	
Falls above Roanal's Ferry	75.78	0.18	337.90	1.45	8.06			2.0 to 3.5	570.60	
Top of Mountain Island Shoals	76.08	0.30	336.50	0.60	2.00			3.0 to 8.0	570.00	Hendrick's mill at 77.45 miles; wheel 10 feet in diameter.
Bottom of Mountain Island Shoals	79.18	3.10	385.02	46.52	15.01				523.48	Line follows canal; average fall approximate; depth not given.
Natural pool	80.42	3.24	386.89	1.87	0.58			3.5 to 18.0	521.61	
Tuckasegee Shoals	83.44	1.02	398.11	11.22	11.00	1.63 in 343.20 feet	24.61	1.7 to 12.0	510.39	Narrow channel on left of island.
Pool	84.01	0.57	399.63	1.52	2.67			3.0 to 11.5	508.87	
Series of small shoals	85.05	1.04	403.99	4.36	4.19	1.73 in 845 feet	10.75	2.5 to 8.5	504.51	
Natural pool	87.14	2.09	406.87	2.88	1.38			2.1 to 10.0	501.63	
Slocum's Shoals	87.32	0.18	408.50	1.63	9.06			2.2 to 4.0	500.00	
Natural pool	88.29	0.97	408.85	0.35	0.36			5.0 to 12.0	499.65	
Fight's Ferry	89.33	1.04	409.45	0.60	0.58			3.6 to 4.5	499.05	
Natural pool	90.74	1.41	410.68	1.23	0.87			2.6 to 13.5	497.82	Hill's mill at 90.83 miles; wheel 8 feet in diameter.
Ross's Falls	91.64	.90	418.81	8.13	9.03	1.50 in 348.5 feet	22.73	2.0 to 9.5	489.69	
Mouth of Little Catawba River, State line	92.887	1.247	423.50	4.69	3.76			1.3 to 8.0	485.00	

Average fall in whole distance 4.86 feet per mile.

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Before making any comments on the natural features mentioned in the foregoing table, the description of the physical character of the river will, as far as my information extends, be completed by the following statement of the geological formations through which it has cut its way.

GEOLOGY.

From its source to the southern boundary of the State, the river flows through the Upper and Lower Lawrentian rocks, affording good building stone of gneiss and granite. East of the Catawba, and near Salisbury, a fine white granite is found, which has been employed in building the United States post-office at Raleigh; but its whiteness has been tarnished and its value as a building stone has been impaired by iron-stains, which appear on the surface of the stone after exposure to the atmosphere.

The characteristic rocks of the Lawrentian series are trachyte, porphyry, syenite, greenstone, and granite, mica being absent in a marked degree. The Huronian formation intersects the Catawba in the great bend, where the strata have a width of from 4 to 5 miles. Its characteristic rocks are quartzite, mica-chist, and clay-slates. Its trend is southwest, broadening toward the south, and it is further characterized by workable deposits of specular and magnetic iron-ore and limonite. In Gaston, Lincoln, and Catawba Counties the iron belt is found in two beds, the thickness varying from 2 to 12 feet. The ore generally occurs in lenticular masses, in beds, at intervals of 1 to 2 miles along the outcrop, and has been reduced at the furnaces to a good quality of charcoal-iron.

Parallel to this bed is another, which is heavy, black, and magnetic, and produces a very tough, malleable iron. According to Professor Kerr's statement, several thousand tons of this ore were mined during the war, and "all the blooms which could be procured at the naval works in Charlotte were used (by the confederate government) for the manufacture of shafts of iron-clads and bolts for the cannon of the coast-forts."

TRADE AND STATISTICS.

The natural obstructions of the river between Old Fort and the State line are so formidable, that it cannot be navigated in its present unimproved condition. Its trade is consequently nothing, and any future trade which is contingent on its improvement must be confined to timber, iron-ore, and agricultural products.

On its head-waters are found fine forests of oak, white and black walnut, chestnut, and locust, and the mountain-tops are covered in the proper season with the bloom of the different-colored rhododendrons and the fruit of the wild gooseberry. Although the beauty of the region has attracted tourists and artists, its inaccessibility has restricted the use of its timber, and only a small portion of the timber-land can be influenced by the improvement of the river.

The following table, compiled from the last census-report, will give the amount of the agricultural product of the contiguous counties, portions of which will be affected by the improvement:

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County.	Population.	Value of farm-products.	Value of live stock.	Wheat.	Indian corn.	Tobacco.	Cotton.	Oats.	Sweet-potatoes.	Irish potatoes.	Wool.
				Bush.	*Bush.*	*Lbs.*	*Bales.*	*Bush.*	*Bush.*	*Bush.*	*Lbs.*
Yancey	5,509	$113,726	$116,311	20,514	113,683	5,211	.....	28,207	164	791	8,980
McDowell	7,592	205,709	124,483	11,955	176,364	300	.....	11,580	4,135	5,394	8,566
Burke	9,777	604,705	175,390	26,528	217,049	25,204	8	31,010	12,342	10,093	6,569
Caldwell	8,476	390,002	228,798	24,455	207,731	27,000	.....	35,313	18,057	19,194	10,462
Alexander	6,068	292,268	167,033	20,142	135,207	19,499	1	37,865	12,581	11,099	11,693
Iredell	16,931	745,445	333,925	67,687	315,972	67,071	408	108,657	11,357	9,552	13,233
Catawba	10,984	350,252	152,563	34,746	142,876	25	22	41,553	5,177	4,540	10,483
Lincoln	9,573	451,857	179,367	42,155	190,286	3,157	242	52,396	12,572	7,914	6,184
Gaston	12,602	817,672	324,926	64,468	338,023	3,640	762	79,717	16,415	9,288	14,763
Mecklenburgh	24,299	1,352,673	580,286	69,826	454,864	5,171	6,067	75,990	18,774	12,159	8,014

Before dismissing the subject of trade, it seems proper to mention in this place that the Catawba affords many sites which command an ample power for manufacturing purposes. I am unable to state the number of large mills in actual operation, but not less than six are scattered along its course. The effect on the milling operations of the introduction of locks and dams should be considered. Although the available water-power will be increased by the dams, it is uncertain whether the mill-owners will be disposed to incur the expense necessary for its utilization, which must be at the sacrifice of existing mill-sites. At the present time the milling interest seems to exceed the interest which demands the improvement of the river, and before the question is finally determined the wishes of the mill-owners should receive proper consideration. In regard to the trade which may be developed by the river, it is difficult to speak with certainty, depending, as it does, on the increase of population, and the investment of capital in farming, lumber business, and the manufacture of iron. For the latter object the banks of the Catawba are well fitted in every respect except that of distance to market.

The utility of the improvement of the river will also be influenced by the railroads which intersect and follow its course. The road from Old Fort, and the road from Charlotte, N. C., meet at Statesville nearly at a right angle; south and west of the lines forming this angle the river takes its course, sometimes intersecting the road, and never more than 10 miles distant from it.

The value of a river-improvement in such proximity to a railroad consists chiefly in the effect of competition to keep down the tariff on freights and in the superior advantages of water-transportation for heavy material.

IMPROVEMENT.

The question of improvement requires for its solution a somewhat different statement of the facts above given. These facts enable me to determine the kind of improvement which is adapted to the peculiar character of the river, and, approximately, the number and height of the dams and the lift of the locks; but the actual cost and the best position for these structures can only be determined with precision after a careful survey.

The Catawba River at Old Fort is 1,274 feet above tide; at the State line it is about 485 feet; the difference of level is 789 feet.

But, in order to divide the river in portions corresponding with the remnants of Mr. Fulton's profile, I have taken Moore's Shoals, about ten

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miles below Morganton, as the head of navigation, and this point seems to be a proper limit because of the more rapid fall between it and Old Fort.

From Old Fort to Moore's Shoals the distance is forty-four miles by the line of the railroad, and the descent is 366 feet. Assuming that the distance, following the meanderings of the river, is one-third greater, then the distance from Old Fort to Moore's Shoals is 59 miles, and the average fall per mile will be about 6.1 feet. From Moore's Shoals to the State line the distance is 92.89 miles and the fall 423.5 feet, giving an average rate per mile of 4.86 feet.

The removal of rocks and sand-bars, and the employment of lateral dams, would have the effect only of improving small sections of the river, but would add nothing toward establishing a continuous low-water navigation. It is doubtful whether it would have any appreciable effect at ordinary stages, or even at high-water. The question can be determined only by a survey.

The average descent per mile masks the real difficulty in the way of improvement. This difficulty consists in the concentration of the fall at special localities and in short distances, instead of being equally distributed over the intervening reaches. The amount of descent at special localities, which is but partially indicated in the average fall per mile, must determine the nature of the improvement to be applied; that is, whether lateral dams, removal of rock, dredging, and all those means which are included under the term "improving the natural channel," can be applied, or whether locks and dams are best fitted to overcome the obstructions to navigation.

As a general rule, streams which exceed the average rate of 4 feet per mile have reached the limit of descent to which the lock-and-dam system of improvement can be economically applied. The cost of improving such rivers becomes so great, that the trade will seldom justify the expenditure.

There are a few instances of rivers having an average descent of 8 inches per mile which can be improved by means of lateral dams.

Applying these two rules to the Catawba, the natural inference is that its improvement is impracticable by lateral dams, and will be very costly if locks and dams are used.

To enable Congress to form an idea of the approximate cost of making a continuous navigation of 3 feet water, at ordinary stages of the river, from Old Fort to the State line, I have subjoined a statement of the number of the dams and lift of the locks required for this purpose. I have also given the approximate cost as far as the width of the river was known.

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Location.	Distance from Moore's Shoals.	Lift of locks.	Cost of locks.	Length of dams.	Height of dams.	Cost of dams and guard-walls.	Length of reaches or natural pools.	Cost of dredging and wing-dams.	Cost of locks and dams and dredging.
	Miles.	*Feet.*		*Feet.*	*Feet.*		*Miles.*		
Ford's Island	6⅜	10½	.....	.....	20	.....	.....	.....	.....
Gunpowder Shoals	8⅜	10½	.....	.....	17½	.....	1½	.....	.....
Keller's Fish-Trap	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oxford Shoals	17½	17½	.....	.....	23	.....	9	.....	.....
Great Falls	19½	9	.....	.....	13½	.....	2	.....	.....
Druin's Island	23	14½	.....	.....	18½	.....	3½	.....	.....
Sherrill's Mill	25½	19	.....	.....	22½	.....	2½	.....	.....
Craggy Rocks	26	14½	.....	.....	18½	.....	½	.....	.....
Below Perkins's Fish-Trap	29	17½	.....	.....	21	.....	3	.....	.....
Island	38½	18	.....	.....	22	.....	9½	.....	.....
Below Litten's Ford	40⅜	19½	.....	.....	23	.....	2	.....	.....
Sherrill's Ford	42	17	$85,000	430	20	$49,800	1½	.....	$134,800
Mayhew's Fish-Trap	48	17	85,000	450	20	52,000	6	.....	137,000
Near Jackson's Fish-Trap	.....	.....	.....	.....	.....	.....	.....	$10,000	10,000
Below Cathey's Island	58½	15	75,000	452	19	60,800	10½	.....	135,800
Below Connor's Island	62½	13	65,000	760	17	55,000	3½	.....	120,000
Half way between Connor's and Nant's Islands	63	9½	49,800	650	13	42,000	½	.....	91,800
Mountain Island Shoal	76⅞	13	65,000	982	16	66,000	13½	.....	131,000
Below canal	78⅜	20	100,000	940	25	84,000	1½	.....	184,000
Above boat-landing	79½	21	105,000	674	25	78,000	½	.....	183,000
Below Tuckasegee Ford	83	12	60,000	848	12	42,000	3½	.....	102,000
Above Mouth Little Catawba	92⅜	13½	67,500	650	17	50,000	9½	.....	117,500
Total	.....	.....	757,300	.....	.....	579,600	.....	.....	1,346,900

This will make the cost of the improvement of the river from Sherrill's Ford to the State line, $1,346,900. Assuming an average width for the river above Sherrill's Ford, the cost of the improvement between Old Fort and the State line will probably exceed $2,000,000.

The scheme in the foregoing statement supposes that 70 feet of fall can be overcome by the amplitude of the *ramous* of the dams, together with a small amount of dredging. The calculations are based on the employment of crib-dams, filled with stone, and on locks having nearly the same dimensions as the Erie and Dismal Swamp Canals, viz, 90 by 18 feet in the chamber.

CONCLUSIONS.

The following general conclusions are based on the data above given, and upon my personal examination:

1st. The Catawba River cannot be improved by means of lateral dams and such other operations in the bed of the stream as are included under the term "improvement of natural channel," so as to afford a continuous low-water navigation from Old Fort to the State line.

2d. A survey will be necessary in order to determine whether, by means of the last-named method, the river can be adapted at mean stages, or even at high-water, to a down-stream navigation for rafts and barges.

3d. The examination for this object should extend over an entire year, and should include the establishment and daily observation of gauges.

4th. An instrumental examination will be necessary to determine the cost of a slackwater navigation.

5th. Slackwater navigation will destroy the present mill-sites, but will increase the available water-power.

6th. The resources of trade are undeveloped. The future trade is de-

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pendent on the increase of the agricultural products, on the investment of capital in iron manufacture, and on better access to the timber-lands; and all these will depend on the increase of the population.

7th. The importance of continuing the improvement through South Carolina to the mouth of the river, on the Atlantic coast, should be considered.

8th. A survey organized in the manner described in my report on New River, dated February 7, 1875, will cost $5,500.

A tracing of the river from Sherrill's Ford to the South Carolina line, (48½ miles,) and a profile from Moore's Shoals to the same point, (92¾ miles,) accompany this report.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

G 17.

SURVEY OF A LINE TO CONNECT THE WATERS OF THE NEUSE AND CAPE FEAR RIVERS, IN NORTH CAROLINA, AND OF A LINE TO CONNECT THE WATERS OF NORFOLK HARBOR, IN VIRGINIA, WITH THE WATERS OF THE CAPE FEAR RIVER, AT OR NEAR WILMINGTON, N. C.

UNITED STATES ENGINEER-OFFICE,
Washington, D. C., February 21, 1876.

GENERAL: The act of Congress approved March 3, 1875, contains a provision for an examination and survey of two lines, which are described as follows, viz:

> Of a line between the Neuse and Cape Fear Rivers, in North Carolina, with a view to connect the waters of the same; and a like line, with a view to connect the waters of Norfolk Harbor, in Virginia, with the waters of the Cape Fear River, at or near Wilmington, N. C.

This duty having been assigned to me by your letter bearing date March 22, 1875, I have now the honor to submit the following report.

It was necessary to place a party in the field during the heat of summer, in order to be able to report by the meeting of Congress, but as exhaustive surveys of all the possible routes could not be made during the intervening time, I was compelled to limit my attention to those routes which appeared to be most feasible.

The act specifies, generally, two lines. The first, designated as "a line between the Neuse and Cape Fear Rivers," was surveyed by Colonel Kearney in 1837, but, as his report could not be found at the time of organizing my party, it was thought proper to resurvey it. After the conclusion of the survey, the report was found. The Kearney route commences at Bannerman's Bridge, near the navigable channel of the northeast branch of the Cape Fear River, and, passing near Onslow Court-House, terminates on the navigable channel of Slocum's Creek, 3½ miles from the Neuse River.

The second route, designated in the act as a line "to connect the waters of Norfolk Harbor, in Virginia, with the waters of the Cape Fear River, at or near Wilmington, N. C.," I propose to call the "coast line or route." It follows the route of the Albermarle and Chesapeake

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Canal and the sounds of Currituck, Albemarle, Croatan, and Pamplico, which afford a navigable channel for more than one-half the distance. With the exception of Pamplico and Currituck Sounds, and portions of North Landing and North Rivers, good charts have been prepared by the United States Coast Survey.

Between Beaufort Harbor and Wilmington, however, no hydrographic examination has ever been made of the intervening sounds. I therefore directed a hydrographic reconnaissance of this part of the coast, in order to determine the feasibility of a canal or open cut as far as Wilmington, N. C. An examination of the part of the line or lines between Norfolk and Albemarle Sound did not seem to be necessary at this time, and for the following reasons: 1st. A report on the condition and cost of improving the Dismal Swamp Canal, the natural rival of the Albemarle and Chesapeake Canal, may be found in the report of Colonel Craighill, dated April 30, 1872. 2d. The Albemarle and Chesapeake Canal, although not entirely free from obstructions at low stages of water, yet affords good navigation for vessels of 6½ feet draught. The portions of this route which lie in North Landing River and Currituck Sound require special improvement. The flat in the river and sound require dredging, and the channel through Currituck Sound should be supplied lights, to enable the steamers to pass safely at night.

The large amount of trade which passes through this canal would justify the expenditure of the sum required for lighting and dredging, even if no further appropriation were made for prolonging the route. The two great sounds of North Carolina, with their tributaries, making 1,800 miles of inland navigation, are brought into communication with Norfolk by means of this canal.*

The two lines designated in the act have the same object, and are parts of a general scheme for making an inland channel between Norfolk and Florida, except between the Neuse River and the Cape Fear, and between the Cape Fear and Waccamaw Rivers, (56½ miles,) and between Winyah Bay and Great Peedee River, (45 miles,) nature has already established a navigable channel. These breaks in the line are the only obstacles to a continuous navigation between Florida and the Northern Lakes. The commercial advantages of such a communication are undoubtedly great, and must grow in importance with the growth of the country; but as a defensive measure and a means of transporting troops, provisions, and all the materials of war, the advantages of such communication cannot be overestimated. The natural dangers of the coast would protect the greater part of the line from attack, and such points as are accessible from the sea could be protected by special fortifications.

It is not surprising, then, that this project should have received the early consideration of Government. It was prominent among the projects of the board of United States engineers for internal improvement, composed of Gen. S. Bernard, Col. J. G. Totten, and Mr. I. L. Sullivan, C. E., which existed during the administration of Presidents Monroe and Adams, and directed examinations of portions of the route to be made. The first detailed survey, however, was not made until the administration of General Jackson.

Under an act of Congress passed March 3, 1837, a survey was authorized, beginning at the southern *debouché* of the Dismal Swamp Canal to Winyah Bay, South Carolina. This duty was assigned to the late Lieutenant-Colonel Kearney, United States Topographical Engineers. †

* See Appendixes 3, 4, and 5.

† His report will be found in Appendix 1.

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The general divisions and subdivisions of my report are as follows:

PHYSICAL DESCRIPTION.—*Sea-coast, sounds, main-land, (including geology.)*

DETAILED ACCOUNT OF SURVEYS, *(with estimates.)—Coast-line, Kearney route, (list of maps.)*

GENERAL CONCLUSIONS.

APPENDIXES: 1. *Colonel Kearney's report.* 2. *Historical extracts relating to coast-line,* (1584 *to* 1590.) 3. *Letter of President of Albemarle and Chesapeake Canal.* 4. *Letter of Mr. McAlpine to President of Albemarle and Chesapeake Canal.* 5. *Table showing trade of Albemarle and Chesapeake Canal.* 6. *Table showing products of counties bordering on the sounds.* 7. *Letter of collector at New Berne, and letter of collector at Beaufort, N. C.*

Before giving the results of the survey made under my direction, it is proper to inquire into the degree of permanence which the proposed channel would possess; and, in order to do this, it will be necessary to consider the physical condition of the region through which it would have to pass.

PHYSICAL DESCRIPTION.

The area embraced in the following description will, as far as practicable, be confined to the region contained between an air-line from Wilmington to Norfolk and the sea-coast. These limits may be occasionally transcended, where the operation of natural forces necessitated a reference to larger areas. The description may be arranged under the heads of sea-coast, sounds, and main-land.

Sea-coast.

The coast of North Carolina is over 300 miles in extent. For the greater part of this distance barrier-reefs, or a cordon of long, low, narrow sandy islands, varying from one-fourth of a mile to nearly 4 miles in width, resist the assaults of the Atlantic, and appear for centuries to have maintained the same position in which we now find them. These barrier-reefs are but a part of a larger belt or tract of sand which girdles the continent. On the coast of the United States it spreads under the sea nearly as far as the one-hundred-fathom curve, and extends in the opposite direction westward to nearly the same distance from the coast, or with an average visible width of from 160 to 180 miles. It is composed chiefly of silicious sand, which changes its color and character with the adjacent land and ocean-bottom; mixing with green ooze and mud off Baffin's Bay, becoming yellow in color on the coast of New Jersey, mingling with calcareous particles as it approaches Florida, where its continuity is broken by the coral reefs, to be again resumed on the west side of the peninsula. In Pensacola Bay it has the dazzling whiteness of pure quartzose sand.

The origin of this vast tract of sand may be traced to the high lands and mountains. From the earliest period every mountain has sent its contributions to the sea-coast. Cloven by the frost, worn and eroded by the rains and rivulets, and transported by all these agencies, it at last reaches the sea. Here, while undergoing further attrition, sifting, and dispersion, it becomes subject to those forces which determine the more or less stable outline of the continent.

That so mobile a material as sand should be able to maintain its position and to resist the action of the waves seems at first sight remarkable; and the fact becomes more striking when we find that the more solid parts of our coast, as well as the rocky cliffs of Great Britain, France, and Norway, are being annually degraded and are retreating before the ceaseless gnawing of the breakers. These rocky shores invariably confront a deeper sea than the low beaches of our coast, and the waves hurl with irresistible violence against the faces of the cliffs the detritus which has accumulated at their base. But upon our coast the long, shallow Atlantic slope greatly modifies this action. Here the

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tidal waves and storm-waves, running up the long and shallow incline which forms the bottom, reach the beach with a gradually-diminished velocity. Here the waves encounter the barrier-reefs, which are the resultant of certain forces, all tending to preserve the position of the coast-line. In the preservation of this equilibrium several natural forces concur, and although their value cannot be distinctly stated, their relation and action can be made evident.

Forces modifying the form of the coast.—Before specially designating these forces, it is proper here to describe the contour of the coast line, according to the recent charts of the United States Coast Survey. I refer to the coast of the Carolinas. It will be observed that the trend of the coast, from Cape Henry to within 25 miles of Cape Hatteras, is southeast; for the next 25 miles, to the very point of Cape Hatteras, it is nearly due south, and that at the point of the cape a remarkable change occurs. From the cape the beach turns to the southwest, and between it and Winyah Bay it is indented with three concave bends. The first, called Raleigh Bay, has a chord of 61 miles and a versed sine of 6½ miles, and terminates at Cape Lookout; the second, called Onslow Bay, has a chord of 85 miles and a versed sine of 18 miles, and terminates at Cape Fear; the third, called Long Bay, terminates at Cape Romain, near Winyah Bay, and has a chord of 71 miles, and a versed sine of 15 miles. Here the coast changes its character and becomes transformed into sea-islands, with deeper intervening channels, supposed to have been partly caused by the increased tidal action occurring at this part of the coast, and encountering a soil in which clay has begun to take the place of sand. The three indentations or bays above mentioned may be due to the degradation arising from the oblique action of the storms and to the increased velocity of the littoral currents acting upon a sandy beach no longer held in equilibrium by the forces which have maintained Cape Hatteras in its present position. The degradation would be increased by the eddies and the littoral current naturally arising from the Gulf Stream, which, forced toward the land by the southwest winds or away from it by the northeast winds, would proportionally affect the velocity of the counter-currents. In studying the outline of the coasts, we are led to examine the oceanic currents, in order to ascertain how far they may have exerted a modifying influence. If the ocean has been the shaping power, it will have left its record beneath the surface. We find that the one-hundred-fathom curve conforms generally to the outline of the coast. Its curvature is, however, much flatter, so that while it is about 80 miles distant from the coast of Georgia and Long Island, it is but 30 miles distant from Cape Hatteras. It would, therefore, appear that the "advancing foot of Hatteras" is molded by other forces than the Gulf Stream and counter-currents. That such is the case will appear from the consideration of the several forces which contend for mastery at this cape. As these forces play so important a part in modifying the form of the coast, and hold, in consequence, an equally important relation to any plan for improving the sound, it is proper to mention them specifically.

1. The first I will mention is the Gulf Stream, which has attracted a large share of the attention of the investigators of the physics of the ocean. This stream, leaving the straits of Florida with a velocity of 5 miles per hour, gradually loses its velocity until, off Cape Hatteras, it is supposed to flow at the rate of about 1 mile per hour. Although unceasing in its action, it is variable in direction and velocity, and, under the influence of storms and arctic currents, "flutters like a pennant in a breeze." A correspondent variation takes place in the eddies and counter currents.

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2. Between the Gulf Stream and our coast a cold arctic current extends from Baffin's Bay as far as the Dry Tortugas. The effect of this current (as well as of the eddies) is increased by the Gulf Stream. A southwesterly flow has, from an early period, been observed by navigators.

3. Another force is the tidal wave. This cosmic force expends its efforts twice in 24 hours in a direction chiefly perpendicular to the crest of the wave.* It reaches a maximum when its direction corresponds with the storms. Its agency in modifying the outline of continents is well known to geographers and geologists, and illustrations of its effects might be drawn from the descriptions of the coasts of North and South America, England, Scotland, Ireland, Norway, and France. Whole districts have been washed away on the coast of England, and ships now sail over the site of "former cultivated fields and hamlets."*

4. Another force of less magnitude than the three which have been mentioned exerts a marked influence on the coast of Carolina. It results from the accumulated waters of the rivers which empty into Pamlico and Albemarle Sounds, and which concentrate in these sounds a greater amount of fresh water than can be found in any other equal area (except Chesapeake Bay) on the Atlantic coast of the United States.

It is to the operation of these four forces chiefly that I am disposed to attribute the formation of the barrier-reefs. The sand of the continental sand-belt, heaped up by the waves and winds, is carved and shaped within by the currents of the sound, without by the currents and waves of the ocean; but arrested and held in equilibrium by the inward-pressing ocean and the outward pressing waters of the sound, it has preserved for centuries the outlines of the coast and the general dimensions of the sounds.†

Movements of the sand.—Once raised permanently above the influence of the waves and currents, the sand becomes subject to the winds alone, and assumes the form and character of veritable dunes. These dunes are distributed along the entire Carolina coast, but seem to attain their greatest magnitude between Currituck Sound and Roanoke Island. Three of these sand-hills are marked on the earliest maps of the coast, but have not been laid down with sufficient accuracy to identify them or to determine their rate of movement. Some measurements have been made by the Coast Survey to determine this rate. Their course is known to be southwest, under the influence of the prevailing winds, which are from the northeast.

No opportunity occurred to measure the height of any of the dunes, but I have been informed that several, near Currituck Inlet, have an altitude of one hundred feet. Huts, live-oak trees, and shrubbery are buried by the advancing hills of sand, which, while moving down the beach, steadily and gradually encroach upon the channels of the sounds.

*A modification of the action of this wave is caused by Cape Hatteras, which, according to Lieutenant Moffitt, splits the wave into two segments, which move for a while in nearly opposite directions.

* Mr. Kiddle, writing in "Nature," states that a very marked effect is observed at a depth of five hundred fathoms, and that off Nantucket Shoals, during gales, New York pilots and masters of coasting-vessels assert that sand is frequently left on deck after a sea has broken on board, although the depth of water may be 12 or 14 fathoms. The observations of Scott Russell have proved the great depth at which waves will affect the bottom, and their transporting-power is well known to engineers through the reports on the harbor of Algiers. Admiral Davis has given an admirable *résumé* of the geological action of oceanic currents.

†The action of breakers may be resolved into three forces chiefly: the force of translation, the downward or vertical resultant, and the undertow. The maximum is toward the beach, and brings everything to shore that has passed the first breakers. The tendency of drift and wrecks on this part of the coast is toward the south.

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Even in short periods their advance may be noted, and the direction is always indicated by the steepest side, which is under the lee of the dune. It is probable that the whole bed of sand forming the beach is continually in motion, and that no particle remains long in the same place. In order to determine the rate of the movement of the sand-beach and dunes a long series of observations would be necessary. The movement of the sand-dunes could be traced by connecting their position with the triangulation-points of the Coast Survey and the telegraph-poles of the Signal-Service. This could be done with but little labor or expense.

It is not a matter of surprise, then, that the inlets should be continually opening under the influence of storms, and closing before the advancing tide of sand.

I am indebted to Gen. Albert Myer, U. S. A., Chief Signal-Officer, for the following table, giving the number of gales from eight points of the compass, the total duration in hours, the maximum hourly velocity, the total maximum in miles, and the resultant in miles, at the following points, viz: Norfolk, Cape Henry, Kittyhawk Bay, near Roanoke Island, Cape Hatteras, and Wilmington, N. C.:

Summary of gales during 1875, *from Norfolk to Wilmington.*

	Number of gales from the—								Total.
	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	
Norfolk	3	4	2	2	5	1	1	6	24
Cape Henry	13	19	2	3	5	2	0	19	63
Kittyhawk	14	38	9	1	7	12	6	8	95
Cape Hatteras	4	42	2	5	8	33	1	4	99
Wilmington	0	0	1	0	4	13	1	2	21
	Total duration in hours.								
Norfolk	10	15	7	7	43	5	5	33	125
Cape Henry	81½	196½	9½	18	33	3½	0	150½	492½
Kittyhawk	121	467	106	4	88	98	51	117	1,052
Cape Hatteras	19	510	24	87	62	327	4	16	1,049
Wilmington	0	0	2	0	36	146	8	6½	198½
	Maximum hourly velocity in miles.								Gen. max.
Norfolk	42	42	36	36	31	30	30	42	42
Cape Henry	42	40	36	40	40	30	0	72	72
Kittyhawk	60	56	54	30	40	62	60	65	65
Cape Hatteras	38	45	40	48	45	50	32	30	50
Wilmington	0	0	25	0	36	44	27	35	44
	Total movement in miles.								Gen. sum.
Norfolk	285	435	195	195	1,150	135	135	1,000	3,530
Cape Henry	2,400	5,860	275	540	910	95	0	4,630	14,710
Kittyhawk	4,130	17,335	3,505	110	2,450	3,260	1,625	2,920	39,285
Cape Hatteras	520	14,565	695	2,425	1,775	9,450	115	415	29,940
Wilmington	0	0	50	0	990	4,325	210	195	5,770
	General resultants.								
Norfolk	310 miles toward N. 74° 18′ E.								
Cape Henry	8,587 miles toward S. 9° 56′ W.								
Kittyhawk	16,732 miles toward S. 35° 35′ W.								
Cape Hatteras	5,697 miles toward S. 80° 30′ W.								
Wilmington	5,154 miles toward N. 40° 48′ E.								

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It will be seen that the resultant of all the winds is largely from the northeast, which corresponds with the actual movements of the dunes toward the southwest.

The sand driven seaward by the wind, except, perhaps, so much as may pass beyond the outer breakers, is returned by the waves to the beach, where the sand driven landward under the prevailing northeast wind, the resultant wind, is carried along the beach and distributed over the bottom of the adjacent sound.

As the local and general changes of the coast line and sounds have been supposed to be considerable, it becomes particularly important to ascertain their extent, rate of progress, and bearing in relation to any proposed improvement of the adjacent waters. This can only be done by reference to history and by comparing old maps with those of recent date.

History of changes in the inlets.—Beginning, then, with the northernmost point at old Currituck Inlet, I find an account of its condition in 1713, according to the statement made to Col. William Byrd, (see the Westover manuscript, dated 1733.) Colonel Byrd was employed by the lords proprietors of Virginia in 1728 as one of the commissioners to adjust the boundary-line between that State and North Carolina. According to the Westover manuscript, old Currituck Inlet closed in 1713. Before that date, the sea is said to have entered in such a volume that the water of the Northwest River became brackish. In 1733, this inlet was so nearly closed as to be impassable by any kind of boat. New Currituck was then open, and a New England schooner lying at anchor in the sound. Colonel Byrd gives the draught which could be carried through the inlet as 10 feet, probably, at high-water.*

There is neither breach, inlet, nor opening in this part of the coast at the present time. In fact, as far as Oregon Inlet all the inlets existing at the period of Sir Walter Raleigh's expeditions are now closed. Between the years 1584 and 1590, Sir Walter Raleigh fitted out five expeditions to the coast of Virginia, now North Carolina. The original documents relating to these voyages can be found in Hakluyt's Collection, "imprinted in London in 1600," and in the Voyages and Travels published in Frankfort by brothers De Bry in 1590. The De Bry brothers give in their publication two maps, by Thomas Hariot, a mathematician of eminence, who accompanied the second expedition fitted out by Sir Walter Raleigh. Without these maps it is impossible to understand the references to localities in the original reports made to Sir Walter Raleigh. Several serious errors in relation to the history of the early expeditions, and to the changes which have taken place in the coast-line, have been disseminated by subsequent narrators. In the classic work of Bancroft these errors have not been repeated. Sir Walter's expeditions visited the coast between Roanoke Island and Beaufort Harbor, and the reports of their commanders enable us to partially trace the changes which have taken place since that day. After a careful examination of the original documents and a comparison of the early maps with the recent maps of the Coast-Survey, I have reached the following conclusions:†

1. That no inlet existed at Nag's Head between the years 1584 and 1590.

*The inlet described by Colonel Byrd as near the initial point of the boundary-line is north of the point marked on the recent maps as the position of old Currituck Inlet. This position of the old inlet is either wrong or another inlet must have existed at the time of Byrd's visit. (See maps of boundary-line accompanying this report.)

†See Appendix 1 for condensed history of Raleigh's expeditions and remarks.

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2. That Raleigh's fleet generally anchored in the roads outside, sometimes near Cape Lookout, sometimes near Cape Hatteras, and occasionally near Ocracoke or Oregon Inlets.

3. Occasionally the fleet, or some of the vessels, entered Ocracoke or Hatteras Inlets.

4. The expeditions and landings *in* the sounds were made chiefly in fifty-ton vessels, "pinesses," and small row-boats.

5. Sir Francis Drake's fleet anchored in the roads.

6. Roanoke Inlet is represented as open in 1738, according to Wimble's chart, also by Lawson and others, and by the Atlantic Neptune map of 1780.

Wimble's chart represents a sloop steering for Roanoke Inlet, a bark for Ocracoke, and a ship for Beaufort Harbor. With the exception of Roanoke Inlet, these symbols would be correct at the present day. Hariot (1585) employs the symbol of a sinking ship to represent the condition of the inlets between Roanoke Island and Cape Hatteras. Lawson, in 1708, gives the earliest account I can find of Roanoke Inlet. He represents 9 feet of water on the bar, (probably at high-water.)

The depths given by Lawson are much greater than those given by other authorities. All the reports made to Sir Walter Raleigh concur in representing Wokokon (which agrees in position with Ocracoke Inlet) as the only inlet where any of the fleets entered. This is Mr. Bancroft's opinion. The name of "Hatorask," which frequently occurs in the original reports, must have referred to Oregon Inlet, or some inlet near by. Subsequently the name was transferred to Cape Hatteras.

The early charts are nearly correct in latitude, but in longitude the error is often twice the actual distance. This will be apparent upon an examination of Wimble's chart, which accompanies this report.

In 1819 the board of internal improvement of the State of North Carolina applied to the University of Oxford and to Lord Egremont for such of Dr. Hariot's papers as related to the expeditions of Sir Walter Raleigh. This "application was politely attended to and search made for such papers, but none could be found. The board have therefore lost the power of getting a copy of the first chart of Ocracoak." I have the pleasure of submitting copies of the maps of Hariot above referred to.

South of Pamplico the shore-line, as has been stated, is subject to a different action from that to the north of Cape Hatteras. With the exception of Beaufort Harbor, the inlets are shallow, the sounds small, and the tributary rivers, with the exception of New River, not navigable. The early discoverers made no attempt to land on this part of the coast. The permanence of the coast-line can only be determined by comparing its present condition with its condition at the time of the first triangulation made by officers of the United States Coast Survey. Local testimony seems to indicate that the beach is washing away between New River and Masonborough, and some of the residents affirm that the beach has retreated as much as one-eighth of a mile in the last twenty years. Although this is not an established fact, yet the statement is of sufficient importance to require verification before a canal near the coast-line can be recommended.

The dates of the existence and opening or closing of the inlets along the Carolina coast, as far as can be gathered from maps, charts, official reports, and histories for the last three hundred years, are given in the following list.

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Table showing comparative conditions of the inlets on the coast of North Carolina at different dates.

O indicates open at time, C closed, — not given.

Names of inlets.	Condition as shown by map of—										Remarks.
	Hariot, 1585.	Lawson, 1708.		Wimble, 1738.	Mouzin, 1775.		Atlantic Neptune, 1780.	Lewis, 1795.	United States Coast Survey, 1875.		
	Condition.	Depth in feet.	Condition.	Depth in feet.	Condition.	Depth in feet.	Condition.	Condition.	Condition.	Depth in feet.	
Currituck	O	8	O	10	C	—	C	C	C	—	
New Currituck	C	—	C	—	O	7	O	O	C	—	Closed in 1828.
Caffey's	O	—	C	—	C	—	C	O	C	—	Closed in 1800.
Roanoke	O	9	O	8	O	8	O	O	C	—	
Oregon	O	—	O	—	O	—	O	O	O	6	Known as New in 1738, as Hatorask in 1590, as Gunt in 1775, as Gant in 1795.
New	C	—	C	—	C	—	C	C	O	—	
Loggerhead	C	—	C	—	C	—	C	C	O	—	
Chickinoke	C	—	O	—	O	9	O	O	C	—	Known as Chickinockcominock in 1775.
Hatteras	O	17	O	9	O	—	O	O	O	14	
Ocracoke	O	13	O	17	O	17	O	O	O	11½	Known as Wokokon in 1590, as Okeracock in 1738, as Occacock in 1775.
New	O	—	O	6	C	—	....	C	O	—	
Norman's	O	—	O	3	C	—	....	C	C	—	
Drum	O	—	O	3	C	—	....	C	C	—	
Cedar	....	—	C	—	C	—	....	C	C	—	
Beaufort	....	13	O	15	O	15	....	O	O	12	Known as Core Sound in 1708, 1738, 1775.
Bogue	....	—	O	9	O	9	....	O	O	6	Known as Boug in 1738.
Bear	....	—	O	11	O	—	....	O	O	5	
Brown's	....	—	O	—	O	—	....	O	O	1	
Little	....	—	O	—	O	6	....	O	C	—	
New River	....	—	O	—	O	5	....	O	O	3½	
Stump	....	—	O	—	O	7	....	O	C	—	
New Topsail	....	—	O	10	O	10	....	O	O	8	
Old Topsail	....	—	O	—	O	—	....	O	C	—	Known as Sandy in 1738.
Rich	....	—	O	—	O	—	....	O	O	2½	Known as Reach in 1738.
Queen	....	—	C	—	C	—	....	C	O	1½	Open in 1868.
Barren	....	—	O	6	O	—	....	O	O	4	
Sandy	....	—	C	—	C	—	....	C	O	1	Open in 1871.
Broad	....	—	O	—	O	—	....	O	C	—	
Shoal	....	—	C	—	O	—	....	O	C	—	
Masonborough	....	—	O	—	O	—	....	O	O	4½	Known as Cabbage in 1738 and 1775.
New, (entering Cape Fear River.)	....	—	C	—	C	—	....	C	O	9½	Open in 1774 according to map of John Collet, and in 1806 according to map of Cole & Price; now (1876) being closed by Colonel Craighill, Corps of Engineers.
Cape Fear River	....	17	O	19½	O	14	....	O	O	12½	

Depths given by Wimble are evidently high-water depths, from remarks in the note. Lawson and Mouzin probably high-water depths, also, from their greatness. To obtain depths corresponding to present low-water depths, deduct for rise of tide: at Currituck, Roanoke, Chickinoke, Hatteras, New Norman's, and Drum, 2 feet; at Ocracoke, Bogue, New Topsail, and Barren, 3 feet; at Beaufort, 2.8 feet; at Bear, 4 feet; at New River, 1.95 feet; at Cape Fear River, 4½ feet.

Sounds.

In the following description of the sounds, I have taken their dimensions from charts of the United States Coast Survey. A short statement of their salient features, present condition, and probable changes has been added. Until the probable deterioration of the navigation is

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ascertained, it would not be advisable to commence any extensive improvement of the channels. For this reason, Colonel Kearney held in reserve his opinion of the feasibility of such improvements.

The following account, which tends to establish confidence in the permanence of a judicious improvement, will not, I think, be regarded as unnecessary. The sounds of the Carolina coast commerce in latitude 36° 45′. The first two are small, irregularly-shaped bodies of water, called North Bay and Back Bay. The latter (which is the larger) is about 9 miles long and 6 broad. By a narrow channel (called Knott's Island Channel) it is connected with *Currituck Sound*. This narrow and shallow sound extends along the coast for a distance of 35 miles. Its width is made variable by islands and projecting points of sand. Opposite Currituck Court-House its width is 7 miles, but for the greater part of its length it varies from 3 to 4 and 5 miles. Currituck is fed by two rivers chiefly—the North Landing River, which is the outlet of the Albemarle and Chesapeake Canal, and the Northwest River, mentioned by Colonel Byrd in the Westover manuscript. These rivers drain large swampy areas, (the Northwest River heading in the Dismal Swamp.) The lower portions wind tortuously through large swamps covered with cypress and gum, and through extensive grass-marshes which border the sound. Occasionally a narrow tongue of sand will be observed, covered with short-leaved pine. The water in these rivers, and in fact in all the fresh-water rivers of this region, is of a transparent coffee-color, due probably to tannin, and contains but a small quantity of sediment. The current being slight, the changes of the course and depth are consequently slow, and are caused chiefly by gradual accretions of aquatic plants, mosses, grasses, and marsh-shrubs. In casting the eye over the extensive swamps and marshes, it is easy to trace the former limits of the sounds.

These marshes are built up by sands from the beach, and by slowly-accumulating vegetable growth. There are no inlets at the present time into Currituck Sound. The water is usually fresh, although in dry seasons it occasionally becomes brackish.* The inlets mentioned in the Westover manuscript were finally closed in 1828. Since this date the shoaling near the coast and in the lower part of the sound has increased with the drifting sand and the growth of aquatic plants. Extensive flats have been formed, which are the resort of canvas-back ducks, geese, and swans, and have been purchased by sporting clubs of Baltimore, Philadelphia, and New York, who visit this region every autumn. The depth of this part of the sound varies from 2½ to 3 feet. The bottom is composed of sand, with occasional patches of oysters, the relics of the salt-water period. The west or northwest part of the sound being better protected from the drifting sand, and also by its depth and width from the encroachments of the marshes, has preserved its original depth. The route of the steamers between Norfolk and New Berne is through this part of Currituck Sound. The Albemarle and Chesapeake Canal commences on the Elizabeth River, 12½ miles from Norfolk. The length of the first section of the canal is 12½ miles. It has one tide-lock 220 feet in length, 40 feet wide, and with 8 feet on the miter-sill. From the end of this canal to the mouth of North Landing River is 18 miles. From the mouth of the river to the second section of the canal in North Carolina is 12½ miles. The second section is 5½ miles long, without locks. From the terminus of the canal to Albemarle Sound is 12 miles. The channel through Currituck Sound is from 6½

* This is due to the salt water which passes through the canal-lock from Elizabeth River.

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to 7 feet deep with ordinary winds. It is difficult for steamers in foggy weather and at night to keep in the channel, and it is here that navigation might be improved by dredging and marking the terminal points with lights.

Albemarle Sound.—Albemarle Sound is almost a fresh-water lake. It is so seldom and so slightly brackish that most of the pilots are ignorant of the fact. This would appear to have been its condition in 1585, when Lane described it as "all fresh water and the channel of great depth and navigable for good shipping," a statement which may be regarded as an argument against the supposed existence of Roanoke Inlet at that time. It is 50 miles long, extends in nearly an east and west direction, widening from 5 miles at the western end to 15 miles at the eastern end. Its depth in mid-channel is 23 feet, but it is shallow along the border, and shoals project in a marked degree from the points at the mouths of the rivers along the northern side. On this side of the sound five broad estuaries enter from the northwest, affording an outlet for as many small rivers. The first of these, North River, is the outlet of the Albemarle and Chesapeake Canal; the second is the Pasquotank, the outlet of the Dismal Swamp Canal; the third is Little River; the fourth Perquimans River; and the fifth the Chowan River, which is formed by the Blackwater, Nottaway, and Meherrin Rivers. By way of the Chowan River the sound is connected by a deep channel with the Seaboard and Roanoke Railroad at Franklin, Va. The Roanoke River, the largest of all, and bearing a large amount of sediment, enters from the southwest through three delta-formed channels. Two rivers, the Scuppernong and the Alligator, enter on the southwest. These two rivers, on account of certain peculiarities, will be again mentioned. There are no lunar tides in this sound. The south and southeast winds elevate and the north, northwest, and northeast winds depress the water. The range, under the influence of the winds, varies from 2 to 4 feet. It has been stated by Hamilton Fulton, civil engineer, that the water of this sound is 2½ feet above the level of the low water of the ocean. This, if true, would be due to the fresh-water drainage. In calm weather a steady current has been observed to set down the sound. From the observation of residents the sound has been increasing its width by the denudation of the headlands. From this cause and the sediment brought down by the Roanoke the sound is always muddy.

The waters of Albemarle and Currituck Sounds find their way to Pamplico Sound by two channels, one on the west and the other on the east of Roanoke Island. The west (and wider) channel is called Croatan Sound; the east, Roanoke Sound. These sounds, so called, are 10 miles long and from 2 to 3 miles wide. The first, excepting a small artificial obstruction, has a good 9-foot channel; the second is intricate, narrow, and shallow. The island, at the time of Amadas's expedition, (1584,) was about 16 miles long and was nearly connected with the main-land by a number of smaller islands. These have been washed away, and the present ship-channel passes over their former position. Roanoke Island has been reduced in width, as well as in length. It is now about 11 miles long. These changes are still in progress, and there are persons now living who can point out great alterations in this locality.* The increased flow of water through Croatan or Roanoke Sounds has been attributed to the closing of Roanoke Inlet. I have already given all the (accessible) authorities for the supposed existence of this inlet. If occasional breaches made by the sea at this point have not been unduly magnified, we must con-

*Mr. Marshall Parks, president Albemarle and Chesapeake Canal Company.

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clude that Roanoke Inlet was not open until after the return of the last expedition, sent out by Sir Walter Raleigh about 1590. It is certain, however, that the present condition of the sounds in question might have been brought about by the action of the wind and waves, which has destroyed the islands and enlarged the channels on each side of Roanoke Island. That temporary breaches may have been formed in this locality is probable. I have been informed by Carlile P. Patterson, Superintendent United States Coast Survey, that a temporary breach was opended during the late war. The uncertain testimony of history in regard to the existence of Roanoke Inlet inspired the hope that an artificial entrance might be made. The importance of this entrance was greatly exaggerated. Under this impression an attempt was made to cut through the beach at Nag's Head and open an inlet near the supposed position of old Roanoke Inlet. A history of this operation and a review of all the plans proposed will be found presented in a very lucid manner in the able report of Colonel Simpson, Corps of Engineers, (1871.) The failure of the attempt to re-open the inlet is instructive. Colonel Simpson reviews the plans of Hamilton Fulton and Walter Gwynn, civil engineers, employed by the State of North Carolina in 1820 and 1840, respectively, and also that of Capt. Hartman Bache and Lieut. D. P. Woodbury. Lieutenant Woodbury, after a review of the plans of his predecessors, presented a modified design. Congress appropriated $50,000, and operations were commenced on the plan and continued until May 13, 1856. Lieutenant Whiting, of the Corps of Engineers, was then assigned to this work, and subsequently, with Col. William Turnbull, inspected the operations. Colonel Turnbull reported to Colonel Abert, chief of Corps of Topographical Engineers, on September 1, 1859, adversely to this work; Lieutenant Whiting had already expressed the same opinion.

Colonel Turnbull states "that $40,000 have been expended, and at this time there is scarcely a trace to be seen of what was done, the drifting sand filling the trench as fast as it was excavated by the dredging-machine." Colonel Simpson concludes his report by stating that any further expenditure would be an unwarrantable waste of public money.

Pamplico Sound.—Pamplico Sound extends from Croatan to Core Sound, a distance of 75 miles. Its width varies from 10 to 18 and 30 miles, its depth in the channel from 7 to 23 feet. Its navigation is limited by the depth of water at Ocracoke, the principal inlet, through which vessels drawing 9 feet of water can pass at low-water, but must wait for high-water before they can pass the bar inside the sound. Under the influence of storms, the bar of Hatteras Inlet is sometimes as good or better than Ocracoke, but the advantage after a short time returns to the latter inlet. These changes have led some observers to infer the probable complete closure of these two important inlets. This result might be hastened if the flow of water through Core Sound were increased by deepening and widening the channel either by natural or artificial means. Should this ever take place, the position of and depth of water on the bar at Beaufort Harbor would be materially changed Upon general principles, it may be predicted that all these changes would be favorable to navigation, but as the status of the inlets which has remained for centuries would thereby be changed, any design made for this object should receive very careful consideration. The distance to sea by way of Beaufort Harbor would be, from New Berne, 35 miles, and from Washington, 29 miles, farther than by Ocracoke.*

*The distance from New Berne to Ocracoke Inlet, is 69¼ miles; the distance from New Berne to Beaufort Harbor, is 94 miles; the distance from Washington to Ocracoke Inlet, is 67 miles; the distance from Washington to Beaufort Harbor, is 96 miles.

The cut which has been proposed between Harlow and Clubfoot Creeks for the purpose of uniting the Neuse River and Beaufort Harbor would reduce the distance between New Berne and Beaufort, and also between Washington and the same point. New Berne would be 29 miles nearer to Beaufort than to Ocracoke, and Washington would, by the same route, be 18 miles farther. The same inlets now exist between the outlying islands, and the same shoals are now found off the coast as were found by the navigators of 1584. Ocracoke or Hatteras appear to have been the first inlets which they entered. The beach, banks, barrier-reefs, or whatever they may be called, appear to have been much wider than at the present time. This seems to have been notably the case near Cape Hatteras. The preservation of the status of the bars at the inlets for so many years indicates a permanence in the relation of the forces by which they are maintained. Should their relations so far change as to destroy the present equilibrium and to close the larger inlets, the deterioration of the interior navigation will not be more rapid than it has been heretofore. At a moderate cost the present channels could be preserved for many hundred years, which is as far as we need look. At the present time the tides near the large inlets vary from 2 to 4½ feet. At New Berne and Croatan Sound they are controlled almost wholly by the winds.

Core Sound.—This sound is 36 miles long and about 3 wide, and connects Pamplico Sound with Beaufort Harbor. The depth near the upper end, on Wimble's chart, is 3 feet; at present it is from 4 to 4½ feet. There are six bars in this sound which have from 4½ to 5½ feet of water over them. These are Harbor Island, two bars at Drum Shoal, Piney Point Shoal, Yellow Shoal, and Bell's Shoal. These should be removed in order to bring the navigation up to the standard of the Albemarle and Chesapeake Canal.

The tide in this sound is neutralized by the meeting of flood-waters from Ocracoke and Beaufort. The Government attempted to dredge a channel in 1838, but the dredge-boat was accidentally burned before anything was accomplished.

The bar of Beaufort Harbor has from 12 to 15 feet at low-water. This depth is sometimes temporarily increased by storms. It has always preserved the advantage over the other inlets of having deeper water after the outside bar is passed. The earliest maps represent the direction of the channel to be southwest. It is now southeast. Lawson, writing in 1708, represents the depth on the bar as less than at Ocracoke. It has been observed that the harbors on the coast of Carolina which are protected by capes have the greater depth. This is the case with Hatteras, Ocracoke, Beaufort, and Swansborough and the mouth of the Cape Fear River.

Bogue Sound.—This sound extends from Beaufort to New River, a distance of nearly 47 miles. The width varies from 2 to 3 miles, and the depth from 2 to 3 feet. The bars shift with the winds. Near Swansborough the sound is occupied by large salt-marshes, which are intersected by impracticable channels.

Between Bogue Sound and Wilmington are five shallow sounds, with an occasional inlet, where coasters may find a haven. These sounds are called Stump, Middle, Topsail, Masonborough, and Myrtle, and are for the most part occupied by an intricate net-work of channels through which a canoe cannot pass. The storms sweep into the sounds a large amount of sand which the feeble backwater is unable to remove, and large deltas have been formed by the ocean inside the inlets, in a manner analogous to the delta-formations which are built up in the ocean whenever the effluent sedimentary water is in excess of the inflowing water of the sea.

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Another cause of sedimentary deposits is found at the points of equilibrium between the meeting of the waters from two neighboring inlets. These accumulations are increased by the creeks and the washings of the rains. While this process of filling is in progress within the "banks," there appears to be evidence that the beach is undergoing degradation by the storms. The question as to the amount of degradation can only be ascertained after a comparison of the present coast-line with that which existed when the first triangulation was made, in 1850. Until this question is decided the utility of a canal or open channel through the sounds must be uncertain. It is noticeable that, notwithstanding these changes, several inlets afford havens for small coasting-vessels. Bogue Inlet has 6 feet at low-water on the bar, New River 3½, New Topsail 8 feet, Masonborough 4, New Inlet 9½, and Cape Fear 12½. The two last-named afford entrance to Wilmington and Cape Fear River, but New Inlet is about to be closed by crib-work* as a means of improving a lower bar.

New River and Bogue Inlets afford outlets for estuaries and tributary rivers, by which the trade of the adjacent country finds its way to Wilmington. Bogue Inlet, with 6 feet of water on the bar, has a good harbor, which is the outlet for the White Oak River. The principal shipping-point is the small town of Swansborough. New River is a broad estuary, navigable as far as Onslow Court-House, or Jacksonville. Naval stores were shipped to a considerable extent from this point before the war. The inlet is noticeable for the marine delta formed by the sand brought in by the ocean. The State of North Carolina contemplated the improvement of the outlet in 1851. The design submitted at that time, but never carried out, accompanies this report.

A subsequent table gives the distance between Norfolk and Wilmington, the available depth, and remarks on the proposed route by way of the sounds.

Main-land.

Geology.—Having described the formation and some of the changes which have taken place in the banks or cordon of outlying islands which form the coast-line of Carolina, and also the dimensions of and the changes which have taken place in the sounds, I will now describe the physical character and geology of the same district. The geology of the entire coast is comprised between the Tertiary and Quaternary formations. It consists of the Miocene and more recent marls. Enumerating them in the ascending order, the oldest is the greensand, the next the Eocene marl, and the upper the Miocene marl. Greensand marl is found on the Cape Fear River, 25 miles above Wilmington, and on the Tar River. Its superior qualities as a fertilizer are well known in Virginia and New Jersey, where it is found in many accessible positions. The Eocene marl is more generally distributed on the Carolina coast. It consists of white marl, comminuted shells, and coral, heaped up in a manner indicative of wave-action and lignite-beds, including graysand pebbles and a few layers of clay. Miocene marl, or shell-marl, is composed of fragmentary and entire shells accumulated in banks.

The Pliocene and Post-pliocene formations are made up of the peaty beds of swamps, shells, moving sand, and sand-dunes of the beach.

The fertilizing properties of these marls vary considerably, and some of them have to be used very sparingly. This is particularly the case with the Miocene or shell-marls. The stone-marl which underlies New Berne and the adjacent country deserves mention for its superior qual-

* Under directions of Colonel Craighill.

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ity as a building-stone. There are two varieties: one consists of shells of 1 to 1½ inches across, which are firmly cemented by silica. It can be easily worked when first brought from the quarry, but becomes so hard after exposure that it can be used for millstones. Although rough in appearance, it makes a handsome building-stone, and is as enduring as granite. The second variety is a buff-colored rock resembling oolite. Like the more shelly variety, it is plastic when taken from the quarry, but becomes exceedingly hard after exposure to the atmosphere, and retains its power to resist the weather for an indefinite period.

A knowledge of the substrata is of essential importance in determining the character of foundation for bridges and locks and the practicability and permanence of canals or artificial channels. The following records of borings and excavations have semed to be sufficiently important to be preserved for future reference:

NOTES ON BORINGS.

Eastward of the Chesapeake in Northampton County, no marl was reached by several borings at 40 feet depth.

Borings made at Fortress Monroe by United States Engineer Department.

Nature of strata.	Thickness of strata, Feet.	Total depth from surface, Feet.
Marsh-soil	5½	5 to 6
Fine dark sand, clean	12½	18
Angular light-colored sand, containing coarse sand, round pebbles and mud	10	28
Sand and mud, different layers	12	40
Some stone, sand, and mud	5	45
Miocene marl	200	245
(The lowest layer of the last showed some greensand and shells; next hard stone full of shells, probably Eocene.)		
Sand, bluish gray, mixed with mud	16	261
Same, fragments of shell-marl, stone harder	9	270
Softer marl, sky-blue color	43	313

Fossil-shells or marine continuous deposits were 224 feet in thickness.

Near Back River, within a few miles of these borings, the Miocene marl is found within 3 or 4 feet of the surface.

At Norfolk shell-marl was reached at a depth of 40 feet.

Borings at Edenton, N. C., (from notes furnished by Professor Mitchell.)

Nature of strata.	Thickness of strata.	Depth from surface.
	Feet.	Feet.
Sand	8	8
Sand, (different kinds)	5½	13½
Clay	5½	19
Vegetable matter, (probably peat)	3	22
Sand	4½	26½
Blue clay	2½	29
Vegetable matter	4	33
Clay	9	42
Gravel	½	42½
Clay	4½	47
Sand and marine shells	7½	54½
Shell-rock	3	57½
Sand and marine shells	21	78½
Clay and shells	68½	147
Sand and shells	½	147½
Clay and shells	35	182½
Sand and marine substances*	3	185½
Quicksand	2½	188
Clay	2	190

Continuous beds of marl on earth with fossil shells.

* The shells, brought up from 182 feet, resemble those found in the outcroppings of the marl, probably of the Miocene era.

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Clubfoot and Harlow's Creek Canal, (from Professor Olmstead's report.)

Total depth, 16 feet; the several depths not noted.
1st layer—Bluish mold usually found in the swamp, rich and peaty.
2d layer—Potters' clay, yellowish-brown color.
3d layer—This layer, of sand, full of sea-shells and fossil remains of mammoths and elephants. The shells, principally conch, scallop, and clam, such as are now found near Cape Lookout.
4th layer—Soft blue clay, said to be the same as in the adjacent ocean.

Wells dug in the vicinity of Lake Mattamuskeet exhibit the several successive strata, as follows:

A well dug by Dr. Sparrow on the ridge near the lake exhibited the following strata:

Character of strata.	Thickness.	Total depth.
1. Ordinary peaty soil	1½	.....
2. Dry sand, fine, wavy laminæ intermixed with peat-sediment	4½	6
3. Black peat soil, containing roots and earth in places, changing to more clayey	4	10
4. Clay	½	10½
5. Quicksand on soft and fluid marsh-mud		

Mr. Ensly's well, the deepest near the same ridge, and within a mile of the last:

	Total.
1. 7 feet of black, rich, peaty soil	7
2. 2 to 4 feet fine sand, laminated, &c.	11
3. 1 to 3 feet clayey marl	14
4. 4 feet quicksand	18
5. 4 feet blue clay, (cutting like soap,) interspersed with layers of peaty sediment and some roots	22
6. 1 foot or more of black peat earth	23

The morning following, after the well had been dug to a depth of 23 feet, it was found full of water.
Other wells dug at other points give the same strata with variable thickness.

These borings exhibit the immediate presence of the sea during the Eocene period, and its gradual recession from the base of the granite cliffs to its present boundaries. A careful geological survey might even determine the general outline of the bays, sounds, and estuaries which at one time formed a continuous but irregular sheet of water from Long Island to Florida. Such investigation is, however, partly speculative, and I allude to it because of its relation to changes now in progress, which should be taken into consideration in devising an improvement of the navigation as contemplated.

Another branch of the subject, which is also in part speculative, has a similar relation to practical questions of improvement. I allude to the supposed depression or sinking of the coast. This opinion is entertained by intelligent observers and by several geologists. Professor Dana, in his chart of the coast, indicates an area of depression extending along the coast of Georgia. In regard to smaller areas of depression, particularly along the coast of Carolina, I have already given some of the arguments which are generally alleged by those who entertain this opinion. 1st. These are, first, the unusual depth of some of the rivers, which extends up to and under the edge of the banks, which are quaking bogs or floating masses of vegetation, as if the bottom had sunk, leaving the light vegetation to float. 2d. There are basins and channels of unusual depth, such as Albemarle Sound, Alligator River, &c., which may be areas of local depression. 3d. The existence, in North, Chowan, and Alligator Rivers, and in the estuaries bordering Albemarle and Pamplico Sounds, of firmly-rooted and imbedded stumps, 10 to 20 feet below the surface of the water. 4th. In digging wells,

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canals, and ditches, in many parts of the swamps, the trunks of dead and fallen juniper and cypress trees, and also stumps, have been found at the greatest depth reached by the peat-formation. It is maintained that the trunks could not have floated, nor the stumps have settled, to their present position, but that they must have grown on this level. This is the weak point in the argument, and, as I have had no personal opportunity to examine the localities, I offer the statement merely as the opinion of intelligent observers. 5th. In further proof, the character of the substrata, as revealed by the excavation of wells in the vicinity of Mattamuskeet Lake, is also cited. In these wells the lower and more ancient beds of peat are found separated by beds of sand, clay, and earth. This fine sand is found deposited in wavy lines, indicative of the action of a gentle current. It is assumed that the peat could not have grown at this level, and could not have settled through the water, but must have sunk by a depression of the surface, and was subsequently covered by the sand of the estuary. Depression, local or general, rapid in some places and slow in others, is not improbable, but its progress since the discovery of the country has not been demonstrated. The hypothesis, however, affords an explanation of some of the characteristics of the peat-bogs of Hyde County swamp and of the Open-Ground Savanna in Carteret County.

Description of rivers, peat-bogs, and soil.—The tract of land between Norfolk and Wilmington is chiefly a delta-formation of peat-bogs, swamps, and savannas, bordered by bands, and intersected by tongues and islets of sandy and peaty soil. These swamps are locally called *pocosins*, or *dismals*, and are covered with forests of gum, ash, and juniper. They usually occupy the higher levels between the rivers, and drain outward in every direction, except toward the north or west. Between the Elizabeth River and the southern border of North Carolina the swamp-lands cover an area of nearly 4,000 square miles. The Dismal Swamp contains an area of about 400 square miles, and lies partly in Virginia and partly in North Carolina. Lake Drummond, which is in the center of the swamp, is 19 miles from Norfolk. It is intersected on the northern border by the Seaboard and Roanoke Railroad, and also by the Petersburgh and Richmond Railroad. The Dismal Swamp Canal passes through the center of the swamp, and connects Elizabeth River with Albemarle Sound. The canal is 29 miles long and 4 feet deep, with a summit-level, and with locks 90 by 18 feet in the chamber. The summit-level is 9 miles long and 4½ feet above the level of the northern section. The lockage to the Pasquotank River, from the summit, is 20½ feet, and from the same level to the Elizabeth River is 21½ feet. The summit-level is fed by Lake Drummond, which contains an area of 24 square miles, and is 26 feet above tide. The range of the lake between the wet and dry season is about 3 feet. It has been proposed, at a cost of $400,000, to reduce the summit-level and deepen the canal, but a million of dollars would probably be required to bring the navigation to the standard of the Albemarle and Chesapeake Canal. A canal penetrates the swamp on the northern side, connecting Jericho Creek, near Suffolk, with Lake Drummond. This canal was projected by General Washington, who was an owner of part of the stock of the company. The canal was originally 12 feet wide, 4 feet deep, and 10 miles long. It has been chiefly employed to transport cypress and juniper shingles. The timber-lands are very valuable, but are occasionally devastated by fire. The swamp-lands which have been reclaimed and cultivated have generally proved very fertile, producing from 60 to 70 bushels of corn to the acre. The soil of the swamp is everywhere covered with *Sphagnum palustre*,

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a species of marsh-moss, which grows with clusters of white blossoms, which have been compared to the heads of white clover. This moss will grow several feet beneath the water, and combines with water-lilies and other aquatic species to make a matted mass of vegetation 10 to 20 feet in depth. The peat-bogs are never free from water, no matter how dry may be the season. The reason of this is evident: The general level of the country is but little above that of the ocean, and the inclination toward the coast is only 1 or 2 feet to the mile. From an examination of wells, Mr. McAlpine found the subterranean water-slope to be from 2 to 4 feet per mile, according to the season. The water, therefore, cannot be far from the surface, which corresponds so nearly with the subterranean water-slope. The higher swamps are fed by a level tract to the west and north of them, as is indicated by their drainage.

Now, when it is remembered that these peat-bogs are in fact vast sponges of living and decaying vegetation, many miles in extent, it is easy to understand how the water, sufficient to supply evaporation, is continually drawn from the subaqueous strata by capillary attraction.

Swelling with water, the peaty growth expands its border during the rainy season until it occupies all the vacant space of the contiguous lake or fresh-water sound, or oozes in small streams over the adjacent and more solid land. The bottoms of the bogs and lakes are found to be of nearly pure sea-sand. It is the belief of intelligent residents and observers that Lake Drummond was formed by the burning-out of a peat-bog. In proof, instances are cited of tracts which have burned to the depth of several feet and have become lakes. But this is true, not of bogs, but of the peat-soil which is a later condition of the bog-development. Fires have frequently destroyed the juniper-timber of the swamps, and it is not easy to decide whether the burnt trees found in this lake have floated to their present position or were partially burned with the peat-soil where they are now found. It is probable that the trees would have been totally consumed by a fire which burned out the soil to the depth of Lake Drummond, and it is not sufficient explanation to cite the instances of small lakes which have been formed in burned-out areas in the cleared peat-land of Hyde County. Fire, which would readily consume the dry peat-soil, can make no progress in a peat-bog saturated with water. In the absence of information, I would propose as a probable explanation of the existence of the lake, that it may be a part of the former sound or bay which once extended from Chesapeake Bay to Albemarle Sound. The delta-depositions and the contemporaneous growth of salt-marsh, the consequent exclusion of salt-water and subsequent growth of the peat-bogs, are adequate to explain the existence of this lake and of such lakes as are commonly found in delta-formations. As familiar illustrations, I would mention Lake Pontchartrain, at the mouth of the Mississippi, and Lake Cienega, at the mouth of the Magdalena, and delta-formed lakes generally.

The process of lake-formation is traceable on the coast of Carolina as follows: First, the barrier-reefs of long, narrow islands are formed by the action of the winds, waves, and currents upon the shallow Atlantic slope, forming bays and sounds. Salt-marshes next begin to occupy the borders of these waters.

The alluvium of the rivers forms many islands; oyster-rocks obstruct the channel and become the nuclei of shoals and subsequent marshes. The inlets are next closed by storms, or by the drifting sand; the water becomes brackish, and marine life disappears. The salt-marshes now become savannas, which rise above tide, and are covered with grass and a few juniper-trees. By the closing of inlets the water becomes fresh,

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or nearly so, and the *Sphagnum palustre* and other peat-plants begin to encroach on the sound. The peaty matter transported by currents closes the mouths of the channels and of the estuaries, and the water thus secluded becomes a lake, which may, in the end, become wholly a peat-bog. These appear to be the actual stages through which the swamp-lands are now passing, and are the more interesting as exhibiting, on a large scale, the preliminary process in the natural formation of extensive coal-beds.

Upon the southern border of the tract of land between the Elizabeth River and Albemarle Sound are five rivers, already noticed, (the North, Pasquotank, Little, Perquimans, and Chowan.) These rivers terminate in wide and straight estuaries, with solid banks. In direction they correspond with the drainage of the country, and, with the exception of the Blackwater and Chowan, are due to the erosion of the original delta. The Blackwater, on the other hand, may have been formed by the encroachment of the marshes and peat-bogs, somewhat in the same manner as Lake Drummond.

Hyde County swamp.—The peninsula of low and level land, bounded on the north by Albemarle Sound and on the south and east by Pamplico Sound, embraces the most remarkable portion of swamp-land in North Carolina. It covers nearly the entire area of Washington, Beaufort, Tyrrel, Dare, and Hyde Counties, and is stated by Professor Kerr to contain nearly 3,000 square miles. It is remarkable for the fertility of its land, the extent of its lakes and peat-bogs, and for the formation of its rivers and bays. The land about Mattamuskeet was, perhaps, rudely cultivated by the Indians when Amadas visited the city of "Pomeiock," in 1584. Since the settlement of the country it has been under continual cultivation for one hundred years, and still produces, without the the aid of manure or fertilizers, 60 to 70 bushels of corn to the acre. The best land is on the northwestern border of the lake, and lies about 7 feet above tide-water. The land declines from the lake toward the sound and the swamps. Good land usually brings from $75 to $100 per acre. Lake Mattamuskeet, when first visited by Amadas and Lane, (1584–'85,) was from 20 to 22 miles long and 8 feet deep. It was then called *Paquique*. It has frequently overflowed its banks, and the consequent loss and distress became so great that, in 1838, the State of North Carolina appropriated a sum for cutting a canal from the lake to Wysocking Bay, on Pamplico Sound.

The dimensions of the lake have been reduced by draining to 16 miles in length and 5 miles in width and 4 feet in depth. The hard beach laid bare around the lake was composed almost wholly of sea-sand. The theory of intelligent residents is, that the area now occupied by the lake was originally solid peat-land, but was subsequently burned out by fire to its present depth. They assert that numbers of burnt logs and stumps are found in the bottom of the lake. They point out a stratum of ashes beneath a foot of soil which is visible along the ditches on the border of the lake. They will also exhibit localities where, after the soil has been burned to the depth of several feet, the space has been occupied by water. The proofs are of the same kind as those offered to account for Lake Drummond. There is, however, this difference between the two lakes: Lake Drummond occupies the center of a bog, and Mattamuskeet is surrounded by a belt of solid peat-land. On this theory, therefore, Lake Drummond must be the relic of a large and more ancient lake, which has since become a peat-bog; if formed by fire, it must have been of solid peat-soil nearly free from moisture. The proof of the fire theory is, as I have said, insufficient, and, although plausible, is not essential

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to the explanation of the existence of these lakes. Lake Mattamuskeet is always muddy, and holds in suspension a large amount of peaty sediment. Two islands have been formed in the lake in the last fifty years, which cover areas of 100 and of 75 acres, respectively. The peaty-matter, sphagnum-moss, water-lilies, and other aquatic plants have almost choked the canal for draining, and have filled a large part of Wysocking Bay, into which it empties. The fertility of the land upon the border of the lake is so marked that several theories have been suggested to account for it. Col. D. M. Carter supposes that after the fire the water was strongly impregnated with the alkali of the ashes, and, leaching through the soil, neutralized the acid, which is generally in excess in marsh-soils. This theory is certainly ingenious. The fertility, however, may also be explained by the deposit from the ordinary overflow of the lake, which has raised the bank along the border.

North of Lake Mattamuskeet, and near the middle of the tract under consideration, are three smaller lakes, called Scuppernong, Pungo, and Alligator. Lake Scuppernong, the largest, is 7½ miles long and 4 wide. It is from 8 to 14 feet deep, and has a range varying from 1 to 4 feet. A company was formed by Josiah Collins in 1770 for the purpose of draining it. Thirty thousand dollars were spent in making a cut to the Scuppernong River. The descent of the canal is about 18 or 19 feet. In 1840 an examination was made of the swamp between Alligator and Pungo Lakes by two eminent engineers, Walter Gwynn and Charles B. Shaw. A system of canals and ditches was devised by them, which were led south into Pungo River. The State expended $200,000 in these operations.

I have already spoken of the natural processes which may have given to the Scuppernong, the Alligator, and Chowan Rivers their characteristic features, by which they differ in a marked degree from North, Pasquotank, Little, and Perquimans Rivers, situated on the north side of Albemarle Sound. The Alligator River, however, deserves especial mention. Amadas called it "the great river Occam." It may be roughly estimated as navigable for 55 miles. For the first 25 miles from Albemarle Sound it is nearly straight, and has a width varying from 2 to 3 miles and a depth of from 10 to 15 feet. The upper part is tortuous, narrow, and from 10 to 35 feet deep. This depth extends under the bordering fringe of aquatic vegetation, and this in turn is bordered by a quaking-bog, at present covered sparsely with small juniper-trees, which increase in number and give place to cypress and gum as the bog becomes higher.

A short canal through the more solid, dry, and elevated land (under cultivation) enables the steamer to reach Fairfield. The material excavated from this canal was composed of matted roots and black loamy earth, which floats in the water when dry, and readily burns when thrown into the fire. The spongy mass of mud along the border shrinks and disappears on exposure to the atmosphere. The *cut-offs* through this mass of vegetation were made with a crosscut-saw, blocks being floated away after being sawed. The attachment of this vegetation to the firmer bog is so slight that portions are separated by the waves made by the steamer, and, floating in the channel, become the center of large accumulations. The current of the river is due chiefly to the effect of the winds in Albemarle Sound. I have called attention more particularly to this river as exhibiting the difference between the rivers on the south from those on the north of the sound. The latter rivers are, with the exception of the Chowan and its head, marked by erosion. The Alligator River appears to be wholly formed by the growth and encroachment

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of the marshes, peat-bogs, and alluvial sediment which has gradually excluded the waters of the sound. If the process of formation can be expressed by a word, it may be called a river of *exclusion* as opposed to a river of *erosion*. It has been suggested that a cut of thirty miles may be made to unite Alligator and Pamplico Rivers, which would shorten the distance to New Berne and Washington. It is also urged that, by means of such a canal, the winds of Pamplico Sound could be avoided. These advantages are unquestionable, but the cost of such a canal must be weighed against the present unobstructed navigation of the sound.

The soil of Hyde County is evidently the result of the decomposition of peat-bogs. It is black and loamy; much of it is reduced to an impalpable powder, which penetrates the clothes and boots of the pedestrian. It is kept under cultivation by a system of ditching, which is as necessary to a good crop as plowing. The soil has been carefully analyzed by Professor Emmons and Major Graham, of Lexington Military Institute. This analysis is very interesting as indicating the amount of vegetable matter in the soil of the swamp-lands.

	Organic matter in 100 parts.
1. Soil of Dismal Swamp, Virginia, under gum and cypress forest, with some juniper, 2 feet under the surface, near the Norfolk and Petersburgh Railroad.	0 48
2. Soil from gum and cypress land near Lake Mattamuskeet, fifteen years after cultivation	21.11
3. Swamp-land of J. Collins, near Lake Scuppernong, under cultivation twenty-four years	33.38
4. Clay subsoil	7.91
5. Scuppernong Lake, land of Mr. Pettigrew, under tillage fifteen years, taken at a depth of 12 inches	41.31
6. Same land, second year's tillage, 15 inches deep	61.66
7. Same land, under forest growth, 12 to 15 inches deep	65.68
8. Same land, clay subsoil, 2 feet under surface	5.28
9. Scuppernong. C. Pettigrew, newly drained and cleared of forest	67.00

After an examination of a number of analyses, I find, in addition to organic matter, that they are composed of from 60 to 65 per cent. of soluble and insoluble silica, together with small quantities of iron, lime, potash, soda, magnesia, and aluminum. I have been more full in describing this peninsula because it possesses all the characteristics of the swamp-lands in a marked degree, and illustrates the preliminary stage of the formation of a coal-bed.

The remaining portions of the district under consideration can be described more briefly. Bay River Swamp, which lies between the Pamplico and Neuse Rivers, contains from 30 to 40 square miles. Dover Swamp, between the Neuse and the Trent Rivers, contains about 40 square miles; it is remarkable for the elevation of its surface, which is 60 feet above the Neuse and Trent Rivers. Southwest of Pamplico Sound is a swamp separated into two portions by four or five lakes. The northwestern, or high part, is called White Oak Swamp, and is between 33 and 38 feet above tide. The southeastern or lower portion is between the Neuse and Core Sound. It is called Open Ground, Prairie, or Savanna. Repeated fires have left it nearly destitute of trees. The highest point is about 12 feet above tide. The State attempted to reclaim the land by draining in 1855. Mr. Edward Ruffin, who visited the work, found the surface of the swamp dry, but soft and spongy; the upper layer for about 2 feet he states to be a mass of matted roots which, after exposure for a year, had retained their woody texture. The dry sods were light enough to float like cork. "Below this layer was one of 1½ feet, which seemed to be rich black soil almost free from

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roots. Dry lumps of this layer, when thrown into the water, would immediately rise and float." Below this layer he found a subsoil of nearly pure sand.

Clubfoot and Harlow Canal.—Near the west end of this savanna a canal has been proposed to unite the waters of the Neuse River with Beaufort Harbor. The distance from New Berne to the sea by way of Ocracoke Inlet will be very much shortened, and the tortuous and intricate channel of Core Sound will be avoided by vessels bound for Beaufort. About the year 1820 the State engineer, Hamilton Fulton, proposed to cut a canal between the two creeks with a bottom width of 14 feet, a depth of 4 feet, and side-slopes of 1½ to 1. As the water in Clubfoot Creek was about 2 feet above low-water in Harlow Creek, he proposed a guard-lock. He also states that the cutting in some places would be 6 feet above the surface of the water. This canal was subsequently constructed, with, it may be presumed, the proposed dimensions.

The distances by this route are as follows:

	Miles.
From Neuse River along Clubfoot Creek to the canal	4
Canal to Harlow Creek	3¼
Harlow Creek to Newport River	3¼
Mouth of Harlow Creek (through Newport River) to 9 feet water in Beaufort Harbor	2⅜
Total	13

The canal has not been used for many years, and has become nearly filled with sand and mud. Its depth varies from 1 to 2 feet. A map of it accompanies this report.

Of the cost of a cut or canal on this line, as no surveys have been made by me, I am unable to give a detailed estimate, but in order to enable an opinion to be formed of its probable cost I have made an approximate estimate of a cut 40 feet wide, with slopes of 2 to 1:

For cutting the canal, dredging the approaches, and constructing a tide-lock 220 by 40 feet in the chamber, the approximate cost would be..... $411,000

This canal has been proposed as a substitute for the improvement of Core Sound.

Two other swamps remain to be noticed; these are called Angola Bay and Holly Shelter. Both lie east of the northeast branch of the Cape Fear River, and contain together about 150 square miles. An isthmus of low but dry land separates these swamps into two nearly equal portions. The line of survey ran over this isthmus, the highest point of which is 23 feet above tide. The swamps all drain through it, and, like all the pocosins of this region, seem to be highest in the center.

As I have already described the characteristics of these remarkable peat-bogs, composed of matted roots of sphagnum moss and other aquatic vegetation, I will now close my description at the limit of my survey on the banks of the northeast branch of Cape Fear River.

SURVEY OF THE COAST LINE FROM HEAD OF CORE SOUND TO WILMINGTON, N. C.

The survey party was organized with Mr. A. K. Michler, assistant engineer, in immediate charge, and Messrs. J. Heth Harrison and Thomas S. Flood, assistants, with a sufficient number of recorders, sounders, and boatmen. As a good navigable channel, affording not less than from 6½ to 7½ feet of water, can be carried from Norfolk through the intermediate rivers, canals, and sounds as far as Harbor Island, at the head of

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Core Sound, a distance of 158½ miles, the survey was commenced at Harbor Island Bar. The following table gives the distances and depths up to this point:

Waters.	Distances.	Draught.
	Miles.	
Elizabeth River, Norfolk, to Albemarle and Chesapeake Canal locks.	12½	8½ feet.
Albemarle and Chesapeake Canal from Elizabeth River to North Landing River.	8½	N. W. wind, 6½ feet; S. E. wind, 7½ feet.
North Landing River from canal to mouth	18	9 feet.
Currituck Sound from mouth of North Landing River to North Carolina Canal.	12½	N. W. wind, 6.3 feet; S. E. wind, 7 feet.
North Carolina Canal	5½	7 to 9 feet.
North River, from canal to mouth	12	10 feet, except at mouth, which has 7 to 8.
Croatan Sound, from light to Roanoke Marsh light	12½	8 feet.
Pamplico Sound, from Roanoke Marsh light to Harbor Island light.	62	
Total distance	158½	

The following detailed description of the route is condensed from Mr. Michler's report:

Core Sound.—The purpose of the examinations in Core Sound was to verify the charts of shoals deduced from surveys made under the direction of Col. James Kearney in 1837, and subsequently by the United States Coast Survey, in 1866. The shoals examined and the results of the examinations are as follows:

Harbor Island Bar: This bar is formed at the entrance of Core Sound from Pamlico Sound. A thorough examination verified the existing chart in every particular. The borings on the bar proper showed the bottom to be hard, fine, white sand. In the deeper water the material brought up was a sticky black mud. The least depth of water in the channel on the bar is 5 feet. A cut in the line of the present channel would probably remain open, the compactness of the material forming the bar on the north of the cut protecting it from the action of the hurtful winds. The length of the cut would be about three-quarters of a mile.

Drum Shoal: Drum Shoal is located 3½ miles below Harbor Island light-house. A comparison of its present condition with that at the time of the former survey shows no differences to exist. As with Harbor Island Bar, the borings showed hard sand on the shoal and sticky mud in the deeper water. The least depth on the bar, in the channel, is 5 feet. The requisite cut would be about a mile and a quarter in length.

Piney Point Shoal: This shoal is 14½ miles below Drum Shoal. There has been no change in the depth of the water over the shoal since the last survey. A cut was commenced some years ago to shorten the length of the channel, but was never completed. The portion cut has remained unaltered. The material is hard sand and sticky mud, distributed in the same manner as on preceding shoals. The least depth of water on the shoal is 4 feet. The cut through would be about 2½ miles in length.

Yellow Shoal: Is situated 7 miles below Piney Point. The distance between the 8 foot-curves is 3½ miles. The least depth of water in the channel is 4½ feet. The depth of water at the time of the last survey has been maintained, and our borings showed the same bottom, hard sand and sticky mud.

Bell's Point Shoal: This, the last of the troublesome shoals of Core Sound, is located 2 miles below Yellow Shoal and due south of Bell's Point. It is five-eighths of a mile long, and probably but a continuation of Yellow Shoal. The examination proves no changes to have taken place since the last survey. The least depth of water is 5 feet. The material is hard sand and sticky mud.

Generally, there is no tide in Core Sound, the level of the water being raised or lowered by the wind, south and west winds depressing it and north and east winds raising it. The examinations were made at a time when the wind had prevailed from the southwest for six weeks. From a comparison of the present conditions of the shoals with the old charts, it is evident that the accretions, if any, are slow. It is therefore probable that cuts through the shoals would be lasting.

In the hydrographic reconnaissance of the sounds, from Beaufort to the most practicable point from which to join them with the waters of the Cape Fear River, near Wilmington, the maps of the topographical surveys made by the United States Coast Survey, from 1856 to 1873 were used in the location of lines of soundings. In the wide portions of the sounds, three parallel lines of soundings, 100 feet apart, were run

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in the direction of the channel, as pointed out by an experienced sound-pilot, and cross-lines from shore to shore were run where it was considered necessary in order to determine the general contour of the bottom. In the narrower portions only one or two lines were run, according to the width. The tidal observations were rather unsatisfactory, having been made irregularly at different anchorages or camps. The results given are the means of the few days' observations taken at the different points.

Bogue Sound.—Bogue Sound extends from Beaufort Harbor to New River Inlet. For 20 miles below Morehead City the sound is broad but shallow. Numerous shoals are discovered whose *positions* are said to be constantly shifting; but the *depth* of the best water upon them has not perceptibly altered during the last thirty-five years. For 5¼ miles below Morehead City wharf a depth of 8 feet at low water can be obtained; for the next half mile, 7½ feet. It then shoals up considerably, varying in depth from 2 to 5 feet, to beyond Goose Creek Shoal—20 miles from Morehead. The bottom is generally hard sand. A short distance beyond Goose Creek Shoal the marshes begin. The water-way is divided into numerous sloughs and bays, and the sound becomes a marsh intersected by a net-work of channels. From the shoal the water deepens to an average depth of 6½ feet to the marshes, and into Burthen Channel for a distance of 3¼ miles. Taking the most direct route to Swansborough, we, at this point, leave Burthen Channel, which enters Bank Channel, and take a slough 50 yards wide and 1 mile long, leading into Main Channel. Average depth in slough, 2½ feet. We then follow Main Channel, which has an average depth of 6½ feet, for 1⅛ miles, to Swansborough. The mean rise and fall of the tides during the time of observations was 3.2 feet. It was too stormy to make an examination of the bar at Bogue Inlet during the stay of the party in the locality. It is claimed to have a depth of 6 feet at low-water over it. From Bogue Inlet to Cape Fear River the sand-banks—the only barrier between the sounds and the ocean—become much lower and narrower. In times of storms the waves are dashed over and through them by the hurricanes, the sand is carried by sea and wind into the sounds, deposits are made at the meeting-points of the tides from the numerous inlets with which the coast is indented, and communication at mean tide even is often closed. The bars and shoals become the bases of salt-marshes, and their accumulation, which is progressive, encroaches upon the channels, and year by year they are becoming closed. From Swansborough, following the channel to the west of Hoggin's and Dudley's Islands, a depth of 8 feet can be obtained as far as to the entrance of South Cow Channel, the only entrance at low-water communicating with the succeeding sloughs leading to New River Inlet. An extensive shoal bars this entrance, save a very narrow passage running between its northern point and the adjacent marsh. Through this passage and for three-fourths of a mile, only 3 to 7 feet is found, but the remainder of the distance to Bear Inlet—2¾ miles—carries a depth of from 8 to 14 feet. The depth of water over the bar at Bear Inlet at low-water is 5 feet. The tide rises 4 feet. From Bear Inlet the Bank Channel is wide and straight for a distance of 1¾ miles, with a depth of between 7 and 8 feet. Here the communicating slough becomes narrower and tortuous, the islands become more numerous, and the depth of water varying at nearly every cast from 2 to 8 feet until Brown's Inlet is reached. The bottom is as changeable as the depth, being either hard sand, soft sand, mud, or oyster-rock. There is no channel over the bar at Brown's Inlet. The shoals within have changed and increased a great deal since the former survey. The tide rises 5¼ feet at the inlet, but this rise decreases rapidly as we pass into the creeks. It was stated by an old fisherman met here, that to his knowledge the banks *had washed back 50 yards in the past twenty-five years*, the distance being determined by some trees felled by his father which had never been moved. Also, that *the depth of the water in the creeks had decreased some 2 feet in the last ten years. He remembered a storm that had swept the sea over the banks, and inundated not only the marshes, but also the main land and for some distance back.* The banks here become extremely low and narrow, the distance to the main-land less, and the continuous slough so intercepted by others and so circuitous and narrow, (at places barely 10 feet in width,) that the finding of a continuous channel is a difficult task. To the meeting-point of the tides, called "the Crooks," 2½ miles from Brown's Inlet, the depth varies from 2 to 5 feet. From the sand-bar—bare at low-water—formed here, the depth varies from zero to 2 feet to nearly the northerly point of New River Inlet. The depth of water over the bar, from the quicksand formation, varies considerably as the wind prevails from different directions. It has been known to have been cut out to a depth of 15 feet under the influence of a northeast storm, but to return in a few days to its mean depth. At the time of the examination an extremely low tide, 3½ feet, was found. The rise and fall of the tide at the inlet was 1.8 feet. From New River Inlet to off Swan's Point—2 miles—the depth varies from 5 to 20 feet. Bottom hard sand, quicksand, mud, and oyster-rock.

Stump Sound.—Entering this sound, we cross Chadwick's Bay, 1½ miles wide, with a depth of from 1 to 3 feet. From here an intricate slough, having a depth of from 0.5 to 3 feet, leads to Alligator Bay, 3¾ miles distant. From the entrance of Alligator Bay to Sloop Point there is no tide. The bottom is generally soft mud interspersed with beds

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of oyster-rock. As the site of what was Stump Inlet is neared, some deposits of hard sand are met with—probably the remains of silt carried in when the inlet was open. The distance across Alligator Bay is 1⅛ miles; depth of water, 2 to 4 feet. With Alligator Bay, the proportion of water to marsh becomes greater until site of Stump Inlet, 9 miles from the bay, is reached. The depth varies from 1 to 5 feet; average about 2 feet. Stump Inlet is entirely closed and banked.

Topsail Sound.—To Sloop Point, 1¼ miles, the depth varies from 1 to 6 feet. From Sloop Point the communication south is by the Bank Channel. The marsh islands again become larger and the waters more concentrated. Four and a half miles from Sloop Point is New Topsail Inlet, and 7½ miles Old Topsail Inlet. The depth of water to them varies from 5 to 12 feet. New Topsail Inlet has the greatest depth of water on the bar of any examined, having 8 feet. The rise of tide is 2.9 feet. Old Topsail Inlet is entirely closed. From Old Topsail to Rich Inlet, 3¾ miles, an average depth of 6 feet can be obtained. The inner shoals at Rich Inlet have increased greatly since the last survey. The depth of water over the bar is 2½ feet; rise of tide, 3 feet. Five and one-half miles below Rich Inlet, a new inlet, called Queen Inlet, washed in seven years ago. It has 1½ feet of water on the bar. The depth attainable from Rich to Queen Inlet averages 3 feet.

Middle Sound.—From Queen to Barren Inlet, 1¾ miles, the depth averages 9 feet. Four years ago the banks to the south of Barren Inlet were broken through, and a new inlet made. This later opening has been called Sandy Inlet. It has 1 foot of water on the bar, but is said to be fast filling up. The depth over the bar at the old opening is 4 feet; the rise of tide is 3 feet. From Barren Inlet to Masonborough Inlet is 3⅝ miles. The average depth for the first 2½ miles is 5½ feet, and for the remainder of the distance, from 8½ to 13 feet. The bottoms in all the Bank Channels are hard sand.

Masonborough Sound.—The depth, 8½ to 13 feet, continues for 1½ miles beyond Masonborough Inlet, and then gradually decreases to 1 foot at the mouth of Hewlet's Creek, distant 3⅜ miles from the inlet, the point selected as the commencement of the land-line across to Cape Fear River. The depth of water over Masonborough Bar is 4½ feet; the rise of tide is 3½ feet. The shoals within are continually shifting. It is said by old residents that *the ocean beach has washed back one-eighth of a mile during the last twenty years.*

Hewlet's Creek to Cape Fear River.—From its mouth Hewlet's Creek is followed for a distance of 1¾ miles. Leaving the creek here, the line takes nearly a due west course across the sand-ridge for a distance of 3½ miles to Greenfield Creek. Greenfield Creek is then followed to its mouth, a distance of 1½ miles. The mouth of the creek is five-eighths of a mile below Wilmington. The intermediate country is a sand formation; its growth, *Pinus palustri*, with some little oak and cypress. The highest point traversed was 68 feet above low-water, in Hewlet's Creek. Difference of levels of low-water in Hewlet's and Greenfield Creeks, 0.02 foot.

Generally, in addition to the continuous channel-line, examinations of the various creeks leading to the main-land were made, and showed that most of them became bare at low water at short distances from the main channels. The inlets are said to frequently change their positions from north to south, and *vice versa*, as acted upon by different winds. Winds from the north and east have the most influence. The height of the tides in the creeks varies with the wind. The numerous sloughs by their meetings make extensive deposits. At several points the tide was noticed running in four different directions—where the last of the ebb from three of the sloughs met the young flood from a fourth, at the point where the three met to form the fourth. Wherever the action of the tide was felt to any extent, sand was found on the bottom, and generally changed to mud at points where good reasons could be found for its cessation of transportation and deposit. The banks are a system of hills and hollows made by the winds from the ocean. The party were made aware of this influence by the piles of sand heaped up on the windward side of the fishermen's huts, and being covered with sand in the morning when they had slept on these hills.

The following table gives the intermediate and total distances from Norfolk to Wilmington, together with depths of water and remarks on the navigation:

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Table of distances between Norfolk, Va., and Wilmington, N. C., via the sounds of North Carolina.

Points.	Distances between points.	Distance from Norfolk.	Draught.	Remarks.
	Miles.	*Miles.*		
Norfolk, Va				
Albemarle and Chesapeake Canal.	12½	12½	8½ feet	By way of Elizabeth River, improved by United States lights, beacons, and some dredging and dikes, would complete the improvement to North River.
North Landing River	8½	21	{NW. wind, 6½; SE. wind, 7½ feet.	
Currituck Sound	18	39	9 feet	
North Carolina Canal	12½	51½	{NW. wind, 6.3; SE. wind, 7 feet.	
North River	5½	57	7 to 9 feet	
Albemarle Sound	12	69	10 feet	Bar at mouth 7.6 to 8 feet.
Croatan Light	15	84	10 feet	Croatan Channel opens Pamplico Sound and tributaries.
Roanoke Marsh	12½	96½	8 feet	
Harbor Island	62	158½		
Morehead City	39½	197¾	4 to 30 feet	After leaving Morehead City the navigation is rapidly reduced to 3 feet; from thence to Wilmington it is hardly passable by canoe.
Swansborough	26½	223¾	2 to 13 feet	
Bear Inlet	7	230¾	3 to 14 feet	
Brown's Inlet	5½	236	2 to 8 feet	
New River Inlet	8½	244½	*+0.7 to 5 feet	
Stump Inlet	17½	261¾	0.5 to 2 feet	
New Topsail Inlet	8½	270¼	5 to 12 feet	
Old Topsail Inlet	3	273¼	5 to 12 feet	
Rich Inlet	3½	277¼	6 to 7 feet	
Queen Inlet	5½	282¾	3 to 4 feet	
Barren Inlet	1½	284¼	8 to 10 feet	
Masonborough Inlet	3½	288	5 to 13 feet	
Mouth of Hewlet's Creek	3½	291½	1 to 13 feet	
Mouth of Greenfield Creek	6½	297¾	*+68 feet	Across the neck to Wilmington.
Wilmington, N. C	0½	298½	12 feet	

* The sign + here denotes the height *above* tide.

Of the maps accompanying this report, Nos. 5, 6, 7, 8, and 9 give the results of the examination of this coast-line.

ESTIMATE OF THE COST OF DREDGING A CHANNEL THROUGH THE SOUNDS ALONG THE COAST FROM HARBOR ISLAND BAR, AT THE HEAD OF CORE SOUND, TO A POINT OPPOSITE WILMINGTON, N. C., AND OF CUTTING A CANAL THROUGH THE NECK OF LAND WHICH SEPARATES WILMINGTON FROM MASONBOROUGH SOUND.

An estimate of a dike for protecting the channel through Bogue Sound is included. I propose to dispose of the bulk of the excavation so as to form an embankment against the inroads of the sea. The neck of land separating Masonborough Sound from the Cape Fear River is 6⅛ miles (nearly) in width, and the highest point of the ridge is 68 feet above tide. A tide-lock will be necessary at the Cape Fear outlet of the canal.

The difficulties of the route have been fully stated. It cannot be recommended until its permanency is assured after a more thorough examination of the growth of the deposits and the changes of the coast-line.

The following estimate is based on the dimensions of the Albemarle and Chesapeake Canal, and is approximately correct:

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Excavation.—Channel 40 feet wide at bottom, 8 feet deep; side slopes, 2 to 1.

Core Sound, 157,368 cubic yards, at 30 cents	$47,210 00
Bogue Sound, 731,540 cubic yards, at 30 cents	219,462 00
Dike in Bogue Sound, 137,940 linear feet, at $2.50	344,850 00

Excavation.—Channel 40 feet wide at bottom, 8 feet deep; side slopes, 2 to 1.

Swansborough to New River, 2,051,456 cubic yards, at 30 cents	615,436 80
New River to Hewlet's Creek, 4,364,800 cubic yards, at 30 cents	1,309,440 00

Hewlet's Creek to Cape Fear River, (Canal.) Berm, 4 feet; slope above berm, 1 to 2.

Above low-water, 2,695,447 cubic yards, at 20 cents	539,089 40
Below low-water, 525,653 cubic yards, at 35 cents	183,978 55
Tide-lock	80,000 00
Clearing six miles 200 feet wide, at $250 per mile	1,500 00
Fascines six miles, at 30 cents per linear foot	9,504 00
Contingencies, 10 per cent	335,047 07
Total	3,685,517 82

DETAILS OF THE SURVEY OF THE KEARNEY LINE.

This line was surveyed with the object of finding a practicable inland route for a canal between the navigable waters of the Neuse and the northeast branch of the Cape Fear Rivers. Its average distance from the coast is about 30 miles. The length of the line surveyed was 69.57 miles, but the actual length of a summit canal will be 56¼ miles, and the length of a canal at tide-level (which would follow down the southwest branch of the New River across the river itself, and thence up the northeast branch, in all 10 miles) would be about 57½ miles.

The description of the line will follow the course of the survey, which began near Bannerman's Bridge, on the northeast branch of the Cape Fear River, and terminated on Slocum's Creek, about 4 miles from the Neuse River. This distance is naturally divided by the valleys of New and White Oak Rivers into three sections.

First section.—From Bannerman's to New River. The greatest elevation of the line is reached in this section. It is about 200 feet wide, and is, as usual, in the center of a pocosin. It is 54 feet above tide, and 17½ miles from the initial point. The ground on each side for several thousand feet is from 40 to 50 feet above tide. Holly Shelter Creek, which the line crosses near the northeast branch of Cape Fear River, is 120 feet wide. The valley of New River at the point of crossing is about 1,500 feet wide, and 12 to 13 feet above tide. New River, at the end of this section, is 500 feet wide. The length of this section is 27 miles on the line of the survey.

Second section.—From New to White Oak River the distance is 10.23 miles. Two small intersecting streams, Little Northeast River and Grant's Creek, are larger than any of the streams which cross the first section. In this section the greatest elevation ranges from 40 to 44 feet above tide. The valley of the White Oak is on tide-level, and is about 700 feet wide at the crossing. The width of the river is 60 feet.

Third section.—The third and last section is from White Oak River to Slocum's Creek. This might be called the lake section, as it formerly had five lakes near the eastern end. The largest of these lakes is called the Northwest or Big Lake. Its area (by the Kearney survey) is about 4.6 square miles, or rather more than one-fifth the area of Lake Drummond. It is from 6 to 8 feet deep, and was 39 feet above tide in Sep-

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tember, 1875. It can possibly be made to supply half of the summit-level. Lake Ellis has been drained since Kearney's survey. Of the other lakes nothing is particularly known except that they have been partially drained. The high ground in this section is from 27 to 45 feet above tide, descends to 25 feet at 1,000 feet from Slocum's Creek, which affords a good channel 10 feet in depth to Neuse River. This section is 20.93 miles long.

To this general description I subjoin the following detailed account from Mr. Michler's report:

The starting-point of the Kearney survey was at what was known in 1837 as Muster Landing, on the Northeast Cape Fear River, 47 miles above Wilmington, N. C. The locality is now known as Bannerman's. A depth of 11 feet at low-water can be carried up the river from Wilmington to the drawbridge at this place. In running the line to be described, the line run by Colonel Kearney, as obtained from his map and inquiry along the route, was followed as closely as practicable. There being no indications of his exact starting-point, the present line was commenced at a point on the south side of the river, a few feet above the bridge and about 125 yards below the mouth of Holly Shelter Creek. The width of the river here is 175 feet. The rise and fall of the tide, as established from extended observations by private parties who have made some surveys in the locality, is 26 inches. There was a freshet-rise in the river of 1½ feet above high-water, so that it was impossible during the stay at the river to establish a low-water mark. The levels were started from a bench pointed out by one of the engineers who had established it as being 5 feet above low-water. From a point 1½ miles above its mouth the general course of Holly Shelter Creek through its windings is south. At this point it makes a bend, and from Player's to the bend the course is west. Starting at the station on the south side of the Northeast Cape Fear River, near the bridge, the line was traced through the lower edge of Holly Shelter Swamp—having on the lines an elevation above tide-level of but 1 or 2 feet—for a distance of 1¾ miles, to Player's. The swamp is of heavy growth of cypress, gum, maple, and ash, with much water. Cypress knees are numerous. The first high ground is met with at Player's, and a cross-line of levels to the creek—700 feet distant—shows that the elevation found is continuous to the perpendicular bluff rising from the creek. On the north side of the creek the swamp is some 5 feet lower than on the south side. From Player's the line follows the direction of the creek on the south side, passing small cultivated patches and extensive tracts of *Pinus palustris*, across Shaking Creek, to a point nearly due west of Little Lake, an expansion of Holly Shelter Creek. From this point a cross-line of levels was run to the junction of Angola and Holly Shelter Creeks, and the elevation found to decrease. Continuing from the point mentioned the line runs through a swamp of gum, cypress, and black oak, toward and across Little Lake. Midway between these two points a cross-line was run to the south, and the swamp-land found to increase gradually in elevation. Little Lake at the point of crossing is 120 feet in width and 10 feet in depth. Leaving Holly Shelter the line passes through a country alternating between swamp-land and long-leaved pine fields across Watery and Poplar branches and several unimportant little streams, until it reaches a point a little distant from Sandy Run, a tributary of Holly Shelter Creek. Its direction is then along the north side of Sandy Run to the Cow Ford. In order to straighten out the line Kearney's line was left here and the ford crossed. The width of the run here is 50 feet. It is very sluggish, and has a depth of only 1½ feet. Following the edge of the swamp on the south side of Sandy Run for 2 miles we recross it a short distance beyond John Padgett's place, and enter Sandy Run Pocosin, the source of the tributaries of the Cape Fear on the one hand and of New River on the other. The course through the pocosin leads to the head of Hawe's Run. Wherever it was assured, from the topography of the country and from inquiry, that the present line was identical with that of Colonel Kearney, they were found to agree as to distance and levels. It was therefore determined to consider his map and profile from the east side of the pocosin to Ward's Landing correct, and to follow the course of Hawe's Run in search of lower ground. This attempt was successful. This distance by both routes is about the same. Hawe's Run was followed to the southwest branch of New River. At the southwest bridge—near Cox's plantation—the elevation of the southwest branch above low-water in the Northeast Cape Fear at Bannerman's was found to be 2.7 feet. The elevation of the branch at the same point above low-water at New River Inlet has been found by previous surveys to be 3 feet. The line continues along the southwest branch to a point opposite Ward's Landing. Number of miles run in this section, including cross-levels, 29 miles and 500 yards; exclusive of cross-lines, 27 miles. The highest point reached on the line above low-water at Bannerman's bridge was 51½ feet. But little cultivated ground is met with on the route. The few settlers claim that the soil is good, but that there is no way to carry the produce to market, were there any

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Their attention is almost wholly given to gathering turpentine. Outside the swamps, the soil is sand and clay. The swamps are covered with dead trees, bark, leaves, and moss. From Ward's Landing, the line coincides with the navigable waters of New River and its branches—the southwest and notheast—for a distance of 10 miles and 616 yards, to Ball's Landing. From one of Colonel Kearney's witness-trees found at Ball's Landing, the line was traced through the Ethridge place, past Ball's and Lipsey's, and through a dense woods, to and across Little Northeast River. Little Northeast is here 60 feet wide and 4½ feet deep. Continuing, the line follows the north side of Horse-Swamp Creek—tributary to the northeast branch—to its head, and then strikes Grant Creek, which it follows on the north side, crossing Little Grant Creek and going through Aman's plantation to a Kearney witness-tree at Lee's Landing, on White Oak River. Length of transit line, 10 miles and 179 yards. Highest point reached, 43 feet above low-water in Northeast branch of New River. Elevation of White Oak River above Northeast branch, 0.03 foot. Width of White Oak River at Lee's Landing, 200 feet; depth, 10 feet; rise of tide, 18 inches. The section between New River and White Oak River has but little variation in elevation. The formation is yellow clay, with a covering of sand varying from 1 to 6 feet in thickness. The character of the pine changes to old-field pine and more oak and maple is found. It is marked by no extensive pocosins, the swamps being confined to the borders of the creeks. The country along the route is more thickly settled and there are some fine large plantations. Cotton is the principal product. Utilizing the navigable waters of the White Oak, the line proceeds up stream a distance of 1 mile, to Haywood's Landing. From Colonel Kearney's starting-point found here, the line passed through the Jones plantation to Gillett's old place. From Gillett's it was traced through thick woods of gum, oak, maple, and juniper to G. Jones and Scott's, where it nears Hunter's Creek. The line then follows the north side of Hunter's Creek into and through Wild Cat Pocosin—a dark, wild, desolate, unfrequented region—to Big Lake; this lake has a surface area of about 4½ square miles, and an elevation above low-water in White Oak River of 39.35 feet. Crossing the southern portion of the lake and a quarter of a mile ridge lying between, the line enters what is now Lake Ellis Bottom. At the time of the former survey and up to 1860, there was about 3 feet of water in the lake. In 1860 it was drained off for the purpose of making a rice-field of the bottom. It is now nothing but a marsh. Crossing the bottom, the line follows the direction of Spaight's drain-canal through the Donall plantation and Havelock Railroad Station to Rye Landing, on Slocum Creek, 4 miles from its junction with Neuse River, 17 miles below New Berne. The line then coincides with the navigable waters of Slocum Creek, a fine broad stream, to the Neuse River. The length of the line from Haywood's Landing to Rye Landing is 20 miles and 1,632 yards. The elevation of Slocum Creek above low-water in White Oak River is 0.12 foot. The highest point reached was 44 feet above low-water in White Oak River. This elevation was found on a pine ridge running up through the pocosin, which was followed to save cutting. The ridge averages 800 feet in width. Colonel Kearney gives his highest elevation as, corresponding with the elevation of the lake, 38 feet. The difference in the two elevations of the lake can be easily accounted for by the fact that the lake-surface varies with the wet and dry seasons, but, as he followed the ridge just mentioned, he must have intended this elevation of 38 feet to express the elevation of the pocosin near the ridge, which is lower. From Jones's plantation to the east side of Lake Ellis there are but two houses, with small cultivated patches.

The section through which the line passes is thickly wooded, old-field pines predominating. The soil is sand and clay, save in the pocosin. The total length of the line gone over by the party, including cross-lines and navigable waters, was 72 miles and 830 yards. Exclusive of these, 58 miles and 1,671 yards.

I have now to submit two approximate estimates for a canal between the northeast branch of Cape Fear River and Slocum's Creek, which empties in Neuse River. The first estimate is for a through-cut without lift-locks fed at the level of ordinary low-water in the two rivers. The second estimate is for a canal, with summit-level and lift-locks to be fed by Big Lake, and a steam pumping-engine to be placed on New River.

Approximate estimate of the through-cut.—Two tide-locks will be required to prevent the entrance of the high-water at the two extremities of the canal. The relation of the tides and floods of the principal rivers seems to render two locks necessary. The facts are as follows: Taking the low-water of the Cape Fear as a reference, the high-water would be 2.2, the land-flood 7.2. In the southwest branch of the New River, in the river itself, and in the northeast branch of the same the low-water is 2.7, high-water not known. In White Oak River low tide is 2.73, high

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ide 4.23, floods not known. In Slocum's Creek low-water is 2.85, probble high-water 5 feet.

In providing for the reception of intersecting streams into the canal t will be necessary to discriminate between those which bear sediment nd those whose waters are limpid. The following tabulated estimate f this work, which covers all the streams which seemed to require spe-ial treatment, is believed to be approximately correct, and will serve s a guide in making a more thorough examination for the final esti-nate. In it will be found the name of each river, creek, or branch rossed by the proposed canal, also its width, height above low tide, which is 8 feet above the bottom of the canal,) the method of treatment f each, and remarks. All the streams along the route are small, wampy, and sluggish, and may, with a suitable revetment of the bank, be received into the canal without injury.

Estimate of cost of construction of works for draining the streams crossed by the tide-water canal from Neuse to Cape Fear River into the canal.

Stream.	Width in feet.	Depth in feet.	Elevation of surface above low-water in Cape Fear River, in feet.	Mode of treatment.	Cost.	Remarks.
Holly Shelter	120	10.0	6.0	Weir	$6,000	Brick masonry.
Branch	10	0.5	16.0	Drain-pipe	575	
Little Lake	120	10.0	13.0	Weir	15,000	Brick masonry.
Watery Branch	65	1.5	21.5	....do	9,000	Do.
Branch	10	0.5	26.0	Drain-pipe	153	
Do	10	0.8	27.5	....do	153	
Poplar Branch	30	1.0	28.5	....do	365	
Big Gum Creek	40	2.0	29.25	....do	877	
Branch	20	1.0	29.25	....do	327	
Sandy Run	50	2.5	33.0	....do	963	
Do	70	4.0	40.0	Weir and reservoir	22,000	Brick masonry.
Howe's Run	20	1.5	39.0	Drain-pipe	322	
Do	25	2.0	38.0	....do	971	
Do	25	2.0	36.75	....do	935	
Branch	20	1.0	35.0	....do	281	
Do	15	1.5	33.0	....do	240	
Howe's Run	15	1.5	29.5	....do	250	
Do	20	2.0	29.25	... do	265	
Do	20	2.75	28.75	....do	422	
Do	25	2.0	28.0	....do	337	
Do	25	2.0	27.75	....do	337	
Do	30	1.5	25.0	....do	243	
Southwest Branch	50	4.0	23.0	....do	888	
Little Northeast	60	4.5	8.0	Weir	8,000	Brick masonry.
Branch	30	2.0	27.0	Drain-pipe	635	
Little Grant	50	3.0	12.0	....do	404	
Branch	20	1.0	21.0	....do	366	
Do	30	1.5	9.0	....do	660	
Do	25	1.0	14.5	....do	270	
Do	40	1.0	23.0	....do	375	
Wood's Branch	40	1.0	24.5	....do	380	
Deep Creek	40	3.0	24.5	....do	1,492	
Hunter's Creek	50	3.0	24.0	....do	1,604	
Traps					10,800	
Total cost					87,000	

The following estimate includes the total amount of the above table. It gives the total cost of the through-cut made with the same dimensions as the Albemarle and Chesapeake Canal, viz, 40 feet wide at the bottom, slopes of two to one below water and one to two above, with a berme 4 feet wide between, protected by fascines. The depth is 8 feet, the locks 220 by 40 feet in chamber.

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Approximate estimate of a through-cut between the Neuse and Cape Fear Rivers.

Excavation channel 40 feet wide at bottom; depth, 8 feet; side-slopes of water-way, 2.1; berme, 4 feet; side-slopes above berme, 1.2. Above low-water 25,749,433 cubic yards, at 20 cents	$5,149,886 60
Below low-water 4,072,338 cubic yards, at 35 cents	1,425,318 30
Clearing 46¼ miles, 200 feet wide, at $250 per mile	11,625 00
Fascines 46¼ miles, at 30 cents per linear foot	73,629 00
Culverts and drains	87,000 00
Two tide-locks	200,000 00
Contingencies	694,745 89
Total cost	7,642,204 79

Estimate of a canal with a summit-level and six locks, for making a connection between the Neuse and Cape Fear Rivers.

The following table gives the lift of the locks, the height above low water in the Cape Fear, and length of each of the levels of the canal. Six locks will be required:

No. of level.	Elevation above low-water.	Length of level.		Lift of rock to next level.	Remarks.
		Miles.	Feet.		
	Feet.				
1	0	.....	3,939	14 feet, up.....	Level of Cape Fear River.
2	14	1	282	9 feet, up.....	
3	23	6	1,920	9 feet, up.....	
4	32	44	3,180	8 feet, down...	Summit-level.
5	24	3	2,859	12 feet, down..	
6	12	.....	220	.....	Level of Slocum's Creek.
Total.	.....	56¼			

The summit is 32 feet above tide and 44 miles long. The entire length of the canal is 56¼ miles.

Three aqueducts will be required on Holly Shelter Creek, New River, and White Oak River. The estimates are based on designs similar in construction to the aqueduct over the Potomac River at Georgetown.

Water-supply.—In estimating for the water-supply I have assumed the necessity of employing a steam-pumping-engine to be located on New River.

The draining of the lakes and the rapid growth of vegetation make the supply from these sources uncertain, and until further examination of Big Lake I shall not be able to state to what extent its waters will be available. The capacity and certainty of steam-pumping machinery are well known. The great cities of Chicago, Saint Louis, Cincinnati, Louisville, and many others of equal importance, depend on this kind of machinery for the supply of water. The employment of steam-pumps as a means of supplying canals has already been successfully tried on the Delaware and Chesapeake Canal.

The machinery for this canal was erected at Chesapeake City, as I am informed by the secretary of the company, in 1853, and has been in active and successful operation ever since. It consists of a wheel 40 feet in diameter, 10 feet face, turned by two powerful steam-engines, 36-inch cylinder and 7 feet stroke, working two pinions on opposite sides of the circumference of the water-wheel. The water enters at the circumference and passes on, as the wheel revolves, to the journals, from thence

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to the canal-surface by a wide sluice-way. The water is raised 20 feet, or 167 tons per minute=360,000 tons per hour,

During the ten years just past the cost has been as follows, for 11,986 tons of coal, (Cumberland,) $73,457.89.

Wages of engineers and men	$50,741 32
Chandlery and supplies	7,593 23
Repairs and renewals	27,175 70

During the years 1874 and 1875, 2,250,000 gallons were raised 20 feet high every hour, at the expense of 426 pounds of coal for every 1,000,000 gallons, and the average cost of raising 1,000,000 gallons 20 feet high was $2.19.

Assuming a trade 500 per cent. greater than that which now passes through the Albemarle and Chesapeake Canal, the amount of water required for lockage, filtration, evaporation, and leakage, will be as follows:

	For one day.	For one year.
	Cubic feet.	*Cubic feet.*
Lockage 50 prisms a day	6,160,000	2,248,400,000
Filtration, evaporation, and leakage	12,830,400	4,683,096,000
Total quantity of water required	18,990,400	6,931,496,000

The cost of the engine to supply this amount, exclusive of foundations and pump-house, will be $210,000.

The probable amount which may be supplied by Big Lake can be determined by a comparison with Lake Drummond and the quantity which it furnishes to the Dismal Swamp Canal. With data which include filtration, evaporation, and leakage, it may be inferred that Big Lake will supply 2,700,000 cubic feet per day. This would reduce the cost of the pump $55,000.

The objection to this method of filling the canal consists in the great cost of maintaining an engine of such unusual power. The entire height which the water will have to be lifted, after adding 8 feet to make good the contingencies of frictional resistance through pipes and pump, is 40 feet. This will require an engine of 999 horse-power—say 1,000. Such an engine will consume 84,000 pounds of coal in twenty-four hours, or 15,330 tons per annum. Estimating this at $6.50 per ton, (short ton of 2,000 pounds,) delivered, the annual cost of fuel will be $99,645. If, on examination, Big Lake is found to be of sufficient capacity to supply one-half, then the cost of engine can be reduced, and the cost of fuel will be also reduced to $49,827.50. By constructing reservoirs alongside of the locks, and conserving one-half of the water required for lockage, the consumption of coal will be further reduced to one-third the original cost, or to $33,218.* This seems a large sum for fuel, and establishes the importance of making a more minute examination of the ground, with the object of finding a lower level.

Drains and culverts.—Thirty-two small streams and three rivers intersect the course of the canal. Ten of these are from 5 to 16 feet above the surface of the canal. Of those below the surface only five are lower than the bottom of the canal. The rivers will be crossed by aqueducts. The smaller streams will be conducted across the canal in culverts, or by drains or siphon-pipes. The following table gives the estimate of this part of the work:

* Wood could be used for fuel, but the cost would be nearly the same, although in the above estimate a liberal rate per ton for coal has been assumed.

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Estimate of cost of construction of culverts, siphons, and drains on the line of the Summit-Level Canal, from the Neuse to the Cape Fear River. Estimated cost of brick, $20 per M; cement, $3 per barrel; bricklayer, $4.50 per day; laborer, $1.50 per day.

Stream.	Width in feet.	Depth in feet.	Elevation of surface above low-water in Cape Fear River, in feet.	Elevation above or below canal-grade +above, —below, in feet.	Mode of treatment.	Cost.	Remarks.
Branch	10	0.5	16.0	+ 2.0	Pipe siphon	$1,810	
Little Lake	120	10.0	13.0	— 1.0	Brick culvert	20,350	
Water Branch	65	1.5	21.5	— 2.5	do	11,887	
Branch	10	0.5	26.0	+ 2.0	Pipe siphon	640	
Do	10	0.8	27.5	+ 3.5	do	895	
Poplar Branch	30	1.0	28.5	+ 4.5	do	1,972	
Big Gum Creek	40	2.0	29.25	+ 5.25	do	1,936	
Branch	20	1.0	29.25	+ 5.25	do	1,069	
Sandy Run	40	2.5	33.0	+ 9.0	Apron	120	Directly into canal.
Do	70	4.0	40.0	+16.0	Weir	21,000	Into canal.
Hawes' Run	20	1.5	39.0	+15.0	Drain pipe	325	Do.
Do	25	2.0	38.0	+14.0	do	640	Do.
Do	25	2.0	36.75	+12.75	do	604	Do.
Branch	20	1.0	35 0	+11.0	do	240	Do.
Do	15	1.5	33.0	+ 9.0	Apron	110	Directly into canal.
Hawes' Run	15	1.5	33.0	+ 5.5	Pipe siphon	1,007	
Do	20	2.0	29.25	+ 5.25	do	1,908	
Do	20	2.75	28.75	+ 4.75	do	1,944	
Do	25	2.0	28.00	+ 4.0	do	1,126	
Do	25	2.0	27.75	+ 3.75	do	1,142	
Branch	30	1.5	25.0	+ 1.0	do	985	
Southwest Branch	50	4.0	23.0	— 1.0	Brick siphon	9,315	
Little Northeast	60	4.5	8.0	—16.0	Brick culvert	48,440	
Branch	30	2.0	27.0	+ 3.0	Pipe siphon	1,210	
Little Grant Creek	50	3.0	12.0	—12.0	Brick culvert	37,000	
Branch	20	1.0	21.0	— 3.0	Pipe drain	760	
Do	30	1.5	9.0	—15.0	Brick culvert	22,719	
Do	25	1.0	14.5	— 9.5	do	17,097	
Do	40	1.0	23.0	— 1.0	Pipe drain	1,140	
Wood's Branch	40	1.0	24.5	— 0.5	do	1,140	
Deep Creek	40	3.0	24.5	— 0.5	do	4,520	
Hunter's Creek	50	3.0	24.0	0.0	Pipe siphon	4,494	
Total						219,545	

The following estimate gives the aggregate cost of a canal with summit-level (fed by steam-pump) between the Neuse and Cape Fear Rivers:

Excavation, (cut 40 feet wide at bottom, depth 8 feet, side slopes 2.1 feet,) 7,623,550 cubic yards, at 20 cents	$1,524,710 00
Clearing 56¼ miles 200 feet wide, at $250 per mile	14,620 00
Aqueduct bridges: New River, (500 feet long, 44 feet wide)	285,712 00
Holly Shelter Creek, (120 feet long, 44 feet wide)	94,524 00
White Oak River, (600 feet long, 44 feet wide)	327,939 00
Culverts and drains	219,545 00
1 lock (length 220 feet, width 40 feet, lift 14 feet)	170,000 00
2 locks (length 220 feet, width 40 feet, lift 12 feet)	300,000 00
2 locks (length 220 feet, width 40 feet, lift 9 feet)	250,000 00
1 lock (length 220 feet, width 40 feet, lift 8 feet)	100,000 00
Steam-pumps at New River, lifting for evaporation, filtration, and leakage through locks 12,830,400 cubic feet, and for lockage 6,160,000 cubic feet, making a total of 18,990,400 cubic feet in 24 hours; lift 32 feet)	210,000 00
Foundations, engine-house, chimney, &c.	57,000 00
Contingencies, 10 per cent	355,405 00
Total	3,909,455 00

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List of maps of water-line between Norfolk, Va., and Wilmington, N. C.—canal, coast, and sound line.

No. of sheet.	Scale.	Title and description.
1	1/20000	Elizabeth River, Virginia. Compiled from a survey made under the direction of Maj. W. P. Craighill, Corps of Engineers, U. S. A., by Capt. C. B. Phillips, United States Engineers, and from United States Coast Survey charts.
2	1/20000	North Landing River, (head of Currituck Sound,) Virginia and North Carolina. From United States Coast Survey of 1861.
3	1/80000	From North River to Pamplico Sound, (in two sheets,) sheet No. 1. From United States Coast Survey chart of 1860.
4	1/80000	From North River to Pamplico Sound, (in two sheets,) sheet No. 2. From United States Coast Survey chart of 1860.
5	1/80000	Core Sound and Straits, North Carolina. From United States Coast Survey chart of 1866.
6	1/80000	Bogue Sound, North Carolina, from Beaufort to Goose Creek Shoal, July, 1875.
7	1/80000	Bogue Sound, North Carolina, from Goose Creek Shoal to New River Inlet.
8	1/80000	Stump Sound and part of Topsail Sound, North Carolina, from New River Inlet to New Topsail Inlet, August, 1875.
9	1/80000	Part of Topsail Sound and Middle Sound, North Carolina, from New Topsail Inlet to Masonborough, August, 1875. Line between Masonborough and Wilmington, North Carolina, August, 1875.
10	1/80000	Newport River and estuaries, showing Clubfoot and Harlow Canal. From United States Coast Survey chart of 1874.
		Kearney line.
1	1/80000	Canal betwen Neuse and Northeast Cape Fear Rivers, (in three sheets.) Sheet No. 1, from Northeast Cape Fear River, at Bannerman's, to southwest branch of New River, September, 1875.
2	1/80000	Canal between Neuse and Northeast Cape Fear Rivers, (in three sheets.) Sheet No. 2, from southwest branch of New River to White Oak River, September, 1875.
3	1/80000	Canal between Neuse and Cape Fear Rivers, (in three sheets.) Sheet No. 3, from White Oak River to Neuse River, at mouth of Slocum's Creek, September, 1875.
		Maps not numbered.
	1/500000 1/80000	Index map. From United States Coast Survey chart, 1856. New River and bar. From United States Coast Survey chart of 1851, and reconnaissance of S. T. Abert, civil engineer, in 1856.
	1/600000 1/500000 1/250000	Coast of North Carolina from "Atlantic Neptune Atlas," 1780. On same sheet, outline of present coast from United Coast Survey. Boundary-line between Virginia and North Carolina. From Byrd's survey of 1728–'29. Compared with Coast Survey of 1862.
	1/125000	On same sheet, coast of North Carolina from Captain Collet's "Complete map of North Carolina," 1774.
	1/600000 1/250000	Wimble's map of North Carolina, 1738. On same sheet, outline of present coast from United States Coast Survey, "Americæ pars, nunc Virginia dicta," &c. From Harriot's account of Virginia, 1585, a chart of the coast from Chesapeake Bay to Cape Lookout. "The arrival of the Englishmen in Virginia, 1584," from Harriot's account of Virginia in De Bry Brothers' collection, 1590.

I desire to express my appreciation of the ability and energy displayed in the conduct of the survey by Mr. A. K. Michler, assistant engineer, and by Mr. J. Heth Harrison and Mr. Thomas S. Flood, assistants, and by the survey party generally. My thanks are also especially due

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for aid and courtesy extended to me by citizens of North Carolina; particularly to Senator M. W. Ransom, Senator A. S. Merrimon, Governor Brogden, Ex-Governor Vance, Professor Kerr, General Thomas F. Drayton, and Mr. Marshall Parks, president of the Albemarle and Chesapeake Canal Company.

GENERAL CONCLUSIONS.

Coast-line.

1. The cost of a canal by this route would be $3,685,517.82.

2. I would call attention to the changes mentioned in the foregoing report, which may result from destroying the present equilibrium in Core Sound, between the waters of Pamplico Sound and Beaufort Harbor. These changes may be advantageous, but cannot be equally so to all who are interested.

3. Clubfoot and Harlow Canal may be substituted for the improvement of Core Sound as a means of reaching Beaufort Harbor. A survey will be necessary to determine accurately the cost of this canal.

4. The shifting sands in Bogue Sound seem to render a dike necessary for the preservation of the proposed channel. Such a dike may seriously injure the harbor of Beaufort; whether a channel dredged and left without protection will be permanent, is problematical. Special investigation is required to determine the question.

5. South of Bogue Sound the changes in the coast-line and sounds require further examination as to the growth of the marshes, islands, oceanic deltas, and the denudation of the coast.

Kearney line.

In regard to the proposed canal between the Neuse and Cape Fear Rivers, I would respectfully submit the following conclusions:

1. The cost of a canal at tide-level, with two tide-locks, will be $7,642,204.79. The cost of a canal with summit-level and six locks will be $3,909,455. The distance between Norfolk and Wilmington by this route is very nearly the same as by way of the sounds, but by the canal the length to be improved is 60 miles, while by the sound route it is 140 miles, including the intermediate reaches of good water.

2. Either the summit-level or tide-water canal is practicable. The summit-level canal has the disadvantage of locks, but the advantage of being less costly.

3. Neither of these canals (summit-level or tide-water) should be adopted until a more thorough examination can be made, in order to ascertain whether a lower or less costly route may not be discovered.

4. The design of a canal for uniting the Neuse River and Pamplico Sound with the Cape Fear derives importance from being a part of a general scheme for uniting the sounds, which extends from Fernandina, Fla., (with but few interruptions,) to North Carolina, and complete the connection, by means of the intervening canals, with the northern lakes and the Saint Lawrence River. The execution of three sections of canal 56½ miles north of Wilmington, 56½ miles between the Cape Fear and Waccamaw Rivers, and 45 miles between the Winyah Bay and the Great Pedee River, will complete the communication with the harbor of Fernandina, Fla. Isolated from the more general design, the canals under consideration would be of local importance only.

5. Should Congress seriously contemplate the execution of the canal,

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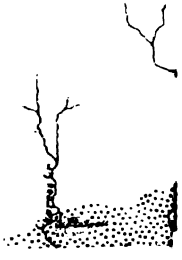

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further surveys and examinations are required in order to determine the best route. For this object $10,000 should be appropriated. Lower ground, affording probably a better location than the line surveyed, may be found between the following points:

a. From the Neuse on the lakes, and south of the lakes, to White Oak River; thence to Onslow Court-House or some point on New River.

b. From Neuse River, by way of Clubfoot and Harlow Creeks, to Newport River; thence from the west end of Newport River to Hodnott's or Pettiford's Creek, on White Oak River; thence to Coon's Head Creek, or some convenient point between Montfort's and Snead's Ferry, on New River; thence from a point on New River, between Stone's Creek and Snead's Ferry, to Lillington's Mill Creek, or Maxwell's Creek, on Northeast Cape Fear River. By keeping as far south and near the sounds as practicable, the cutting may be reduced. Even if Onslow Court-House is a fixed point in the line of canal, it still seems practicable to descend New River as far, perhaps, as Snead's Ferry, before continuing the cut toward Northeast Cape Fear River. Holly Shelter Swamp, no doubt, declines toward the south, and possibly a better line may be found on this route, or south of the higher ground between Holly Shelter and the sound.

As already stated, the funds at my command did not allow surveys to be made of all the routes which seemed to be practicable.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIXES.

1.—REPORT OF LIEUT. COL. JAMES KEARNEY, TOPOGRAPHICAL ENGINEERS.

WASHINGTON CITY, *May* 21, 1838.

SIR: I have the honor to report that, on the receipt of your orders of the 28th March, 1837, assigning me to the surveys near the coast of North and South Carolina, I proceeded to organize the requisite means for carrying them into execution. Some delay was necessarily occasioned by the scarcity of competent assistant engineers and the necessity I was under of seeking them among such of the civil engineers not in the employment of the Government as chanced at the time to be disengaged from other service. I succeeded, however, in forming two parties.

The act of Congress passed the 3d of March, 1837, required the survey to be made from the southern *debouché* of the Dismal Swamp Canal down the Pasquotank River to Elizabeth; thence to Croatan Sound, Pamplico and other sounds, near the coast of North Carolina; and thence by the most practicable route to Winyaw Bay, in South Carolina; with a view to determine the practicability of opening an inland communication for steam-navigation from the Chesapeake Bay to Charleston, S. C. The reconnaissance of part of the line had been reserved by my original orders for another officer. Subsequently, however, the reconnaissance as well as the survey of the whole of it was assigned to me. No examination of the ground, however, was required before the parties began to operate in the field. The frequent professional tours of duty which I had formerly occasion to make near the coast of North Carolina, together with the surveys already executed there for military purposes by officers of the Corps of Topographical Engineers, viz, by Majors Abert and Kearney and by Captain Bache, enabled me at once to draw up the requisite instructions to the chiefs of parties and to assign to them the limits of their operations for the surveys requiring the earliest attention, and the time usually consumed in the preliminary examinations was thereby saved. One of the parties was directed to survey Joyce's Creek and Pasquotank River from the canal to Albemarle Sound, very carefully, wherever especially there should be found a less depth than 8 feet of water, and wherever any obstruction to the free navigation of the creek or river should present itself. A general examination of Albemarle Sound was likewise required in the direction of Croatan Sound for

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the purpose of verifying the existence of a sufficient depth of water for the passage of steam-vessels. This work having been completed, Core Sound and the passage through the marshes were carefully surveyed to ascertain whether any change affecting the navigation had taken place since the period of the surveys made there by Captain Bache. It was intended, also, that the same party should connect, at least by a chain of triangles, the work of Pasquotank River with that of Croatan Sound, and the Roanoke marshes with Harbor Island Bar, the limit of the surveys intrusted to the other party of engineers employed upon the sounds. And it was intended, also, to have taken soundings upon Long Shoal, Bluff Shoal, and other parts of Pamplico Sound. But the advanced season and a desire to preserve the health of the party for the prosecution of the surveys to be undertaken during the autumn of that year, joined to other circumstances not necessary to be here stated, made it expedient, in my opinion, to postpone this part of the work to a more suitable occasion. In consequence of this the party was transferred to Bogue Sound, and it was enabled to make the survey of the part of the line from Beaufort Harbor to Swansboro and Bogue Inlet before the sickly season had begun. The other party of engineers surveyed with great care and very skillfully, under the immediate direction of the intelligent and experienced assistant who had it in charge, the whole of Core Sound, so that nothing further remains to be done there to enable us to form the project and estimate the cost of its improvement in the greatest detail, unless it be at some suitable season during the prevalence of the storms which characterize the spring and autumn, for example, to make such observations as will enable us to ascertain the direction, velocity, and effect of the currents which may possibly prevail there when the winds blow for a long time from the same quarter. On the termination of the survey of Core Sound, I instructed the engineer in charge of the party there to take rapidly some lines of soundings on the bar of Old Topsail Inlet, the entrance to Beaufort Harbor, for the purpose of ascertaining the correctness of an opinion advanced by the pilots, that since my survey of 1822 the depth of water on the bar had materially increased.

These operations being effected, and the sickly season at hand, the engineers were withdrawn from the field to plat their work and arrange the facts which they had collected, preparatory to their resuming the surveys proposed to be made farther inland during the latter part of the fall and the beginning of winter. We had, in a comparatively short time, collected much information; our work had extended itself to a distance of about 220 miles; and, taking into consideration the surveys heretofore made under the direction of the officers of the corps whom I have named, with the observations, the result of various professional visits to the coast, we are enabled to take general views of the character and extent of the improvements of which the sounds, at least as far westward as Cape Fear River, are susceptible; they enable us to form opinions on the question of their probable permanency, the advantages to result to the commerce of the country, and, for a great part part of the distance, we have the means of estimating the probable cost. Especially is this the case with respect to the line from the Dismal Swamp Canal to Swansborough. To the westward of that place, the very close reconnaissance which in the year 1822 I made on the sounds lying toward Cape Fear River, enables us to appreciate their value with reference as well to commerce as to military defense.

The memorandum which I had the honor to submit to your consideration as the basis of a reply to the letter of the Hon. C. Shepard, and other members of Congress from North Carolina, will have made you acquainted with my opinion upon the question of the improvement of Core Sound, the value of such improvement to the coasting-trade and to foreign commerce; and it will have shown the connection of that sound with the navigable waters of the State and with the waters of the Chesapeake Bay. A copy of that memorandum is herewith transmitted, and I have to ask your attention to it in connection with this report.

The practicability and importance of a navigable communication, inland, between the Chesapeake Bay and Beaufort Harbor, viz, by Elizabeth River, the Dismal Swamp Canal, Pasquotank River, and Albemarle, Croatan, Pamplico, and Core Sounds, are unquestionable. It would be out of place in this preliminary report to enter into a minute description of the sounds and rivers embraced by the surveys of the past season; nevertheless, we may state that west of Beaufort the sounds generally are much narrower and with a greater number of shoals than are those I have enumerated. Bogue Sound, though broad, is very shallow. Those lying between it and Cape Fear River are, for the most part, full of marshes, through which we find the passage to be by narrow and tortuous creeks, with extremely shallow bars wherever the tides meet in their passage from the numerous small inlets with which the line of coast is indented. The only barriers between these sounds, generally, and the ocean, are low and narrow sand-banks, over which in many places the waves are swept by the hurricanes; the sands are carried by the sea and the wind into the sounds; shoals are formed, and become the bases of salt-marshes; the accumulation of matter over their whole area and in their channels is thus progressive. The communication between them is sometimes closed by the silt carried forward by the tides, and by the encroachment of the marshes,

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and it becomes necessary to open small canals for the passage of lighters and canoes at high tide. To this description, which is very extensively applicable to the sounds west of Bogue, there are exceptions which it is unnecessary for our present purpose to enumerate, unless it be required in the case of the portion of the sound lying near New River, to which I have referred in the memorandum already alluded to.

It is apparent from these facts, I think, that the question of the practicability and cost of opening a channel for steamboats west of Beaufort, or certainly of Swansboro, yields, in point of importance, to the consideration of the practicability and expense of defending it against the inroads of the sea and the encroachments of the sands. The exposure, too, of this part of the route to the enterprises of an enemy, during periods when it would be most required for the security and accommodation of trade, became so apparent from the facts developed during our examination, that it was deemed advisable to inquire whether a route might not be found farther inland, by which to connect the sounds and navigable waters east of Beaufort with some branch of Cape Fear River. Subsequent inquiry, supported by our previous knowledge of the country, led to the opinion that probably a canal might be constructed of the requisite capacity and with a sufficient supply of water, from Neuse River to the northeast branch of Cape Fear River. The facts and reasoning upon which this opinion rested were verbally communicated to you, and as they received the sanction of your favorable opinion, one of the parties of engineers was instructed to make such surveys and examinations of the country near the presumed line of communication as would enable us to arrive at more accurate and distinct ideas of the adaptation of the ground to the project. On resuming the field-operations, therefore, I organized a party for that purpose, in the stead of the one which had surveyed Pasquotank River and the sounds east of Harbor Island, which had been broken up by circumstances unconnected with the service. This I placed under charge of an experienced and intelligent principal assistant, who had already served under my orders, and who performed the duty entirely to my satisfaction.

The survey commenced at a point on the northeast branch of Cape Fear River, forty-seven miles above Wilmington, and five miles below the head of navigation—8 feet water. The point of beginning was within a few yards of the mouth of Holly Shelter Creek; thence it was traced nearly parallel with that creek, crossing in its course Shaking Creek and several of the minor streams which issue from Holly Shelter Swamp. It crossed Holly Shelter Creek at Outen or Little Lake, and thence followed the course of Big Sandy Run to a location the source of some of the tributaries of Cape Fear River on the one hand and of New River on the other; thence it pursued nearly a direct route to Ward's Landing, on the southwest branch of New River; length, 25 miles 1,639 yards.

Thence the line coincided with the navigable waters of New River and its branches (the southwest and northeast) for a distance of 10 miles 616 yards, viz, to Ball's Landing; hence it was traced by the way of Ethridge's Landing to the head of Grant's Creek, and with that creek to Whitock River, at Lee's Landing, a distance of 9 miles and 1,683 yards; thence 1 mile and 100 yards with the river to Haywood's Landing. From Haywood's the line passed through E. Jones's plantation, and along the north bank of Hunter's Creek, by the southern shores of Big Lake and Ellis's Lake; thence down Spaight's Canal and Slocum's Creek to Rail's Landing, 20 miles and 1,012 yards. Rail's Landing is 1 mile above the forks of Slocum's Creek; from the forks to Neuse River, 4 miles. Slocum's Creek is a broad, navigable stream; it joins the Neuse 17 miles below New Berne. The entire length of the line surveyed by the party is 67 miles and 1,429 yards, including the river and lake navigation; exclusive of these, 53 miles and 22 yards. The highest point in the experimental line between northeast branch of Cape Fear and New Rivers was 41¼ feet above the surface-water of the river at the point of beginning; but this may be materially reduced by following the course of Haw's Run. Between New River and Whitock River the highest point was 43 feet, and between Whitock River and Slocum's Creek it coincided with the lakes, Big Lake being 38 feet and Ellis's Lake 33.7 feet. These lakes were surveyed for the purpose of ascertaining approximately their capacity as reservoirs for the supply of the summit and lockage of the canal, and we are warranted in assuming that a sufficiency of water may be found for these objects upon the summit-level.

The survey now described between Cape Fear River and Slocum's Creek serves only to manifest the practicability of uniting the Cape Fear with the Neuse. Other surveys are required preliminary to the definitive selection and location of the line of canal. These would probably be traced (one of them, at least) between the northeast branch of Cape Fear and Trent Rivers; and another, departing from Munster Landing on the northeast, would follow the course of Haw's Run to Shepard's Mill; thence to Onslow Court-House, to Moss's Landing, on the western prong of the northeast branch of New River; thence to Lee's Landing, on the Whitock River; thence to Big Lake, Ellis's Lake, and Spaight's Canal, to Rye Landing, on Slocum's Creek. This line would be about 56¼ miles long. Its summit-level would coincide with one or other of the lakes, or, being separated from them, it would be placed in a plane sufficiently low to enable

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us to command for the supply of the canal as much of their water as might be deemed requisite. The summit-level would cross the navigable streams at points the least prejudicial, and it might be prolonged to any desirable extent between the points of termination of the canal.

Surveys should be made also to ascertain the practicability, the best means, and the cost of uniting the main trunk of the canal with the harbor of Beaufort by a branch traced in that direction. Its connection with navigation on Whitock River and New River would be directly effected by means solely of locks constructed at the points of passage of those rivers.

To the northeastward of Neuse River it may become advisable to make other surveys, that we may have the means of presenting to Congress a view of all the routes by which a navigable communication might be established between Albemarle Sound and the Neuse. In examining the relative merits of these, and their several claims to attention, the professional views which would most probably influence the mind of the engineer in his selection might not possibly be those to which the legislature would be disposed to attribute the greatest force. There are other reasons which may render it expedient not only to carry the surveys between the Neuse and Albemarle Sounds farther inland, but which may even require us to examine more minutely than we yet have done the two great sounds, Pamplico and Albemarle. The result of such examinations might possibly even affect seriously the character for stability of a portion of the route by the sounds. How far the causes which have operated to close the inlets formerly existing in front of those sounds may have tended also to affect the depth of the sounds themselves, or whether they have had any influence, deserves to be investigated. If we compare the chart of Lawson with that of Cole and Price, we are led to believe that the depth of water off the shoals, at least, is much less than it was in Lawson's time. Nevertheless, the soundings given in one or the other of these charts may be erroneous. It is desirable, I should think, to have this question settled before the adoption of any particular project involving great expense in its execution. A careful comparison of the present depth of water in all the navigable parts of the sounds I am now speaking of, with the depths noted by Lawson, Price, &c., will enable us to determine whether or not the depth is lessening in them, and, if so, the periodical rate of diminution may also be ascertained. The solution of this question might possibly influence the location of the northeastern debouché of the Cape Fear and Neuse division of the canal; and however desirable it might otherwise be presumed to be to carry that as low down the Neuse as practicable, we might find it expedient, under the influence of the facts to be developed by the hydrographic survey, to carry it in the direction of New Berne, Washington, and Plymouth.

The line of canal 56¼ miles in length, between the Neuse and Cape Fear Rivers, which has been described, would suffice to open an inland communication for steamboats from the southern debouché of the Dismal Swamp Canal to Wilmington, N. C., and to the ocean.

The proposed route, via the sounds and Slocum's Creek, would lie parallel to the coast, and, crossing the principal navigable streams of the State of North Carolina, would be found to possess all the advantages of a general line of communication for the trade of those rivers; the rivers themselves not having usually such outlets as would enable the produce of the interior to find an exit by the way of the ocean to other parts.

The same observations will equally apply to the other divisions of the work, viz, that of the Brunswick and Red Bluff division, as also that from Winyaw Bay to Charleston.

It is obvious that such a line of improvement, especially when considered with reference to its direct connection with some of the best harbors on the coast, is of general interest, being equally advantageous to the commerce and defense of the country.

Of the surveys made under the authority of the act of Congress of the 3d of March, 1837, there remain to be described those only which lie to the westward of Cape Fear River, between the Green Swamp and the ocean. The surveys which I had formerly made near Waccamaw Lake and the Green Swamp, led to the opinion that if a navigable communication between the Cape Fear and Waccamaw Rivers were at all practicable upon any line remote from the narrow sounds which border upon the sea, it must be traced between the ocean and the Green Swamp, and that in all likelihood it should rely upon the water yielded by that swamp, and upon such that might be collected nearer the sea for the supply of the summit-level and lockage of the canal. With this view of the subject, and to test its correctness, the party of engineers which had been employed during the early part of the summer upon Core Sound, was, at the proper season, directed to make upon the ground I have just described, such surveys and observations as time and the means at our disposal would permit. Accordingly, that party ran a guide-line of levels and a line with the compass from the Red Bluff on Waccamaw River to Brunswick on the Cape Fear, 16 miles below Wilmington, and extended its observations into the swamps as far as the inundations would permit, for at that time the rains had set in.

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The distance from the Red Bluff to Brunswick, and consequently the length of canal, if it were constructed upon that line, would be about 56¼ miles. The examinations which the party was able to make with reference to the means of supplying the summit-level with water were necessarily very limited; nevertheless, such as they were, they were far from discouraging the expectations of success which had been created by the surveys formerly made farther inland. Whenever the necessary appropriations are made to enable us to resume the surveys, a close and extensive survey and examination of the Green Swamp, and of the country lying between it and the sea, will be undertaken. When these will have been completed, and not till then, can we be authorized to form any decisive opinion upon the question, not of the sufficiency of the quantity of water yielded by the neighboring swamps and lakes, but of the practicability of conducting it to the summit-level of a canal to unite the Cape Fear with the Waccamaw. In the mean time the probability that it is practicable is so strong, in my opinion, as to justify the Department in prosecuting the inquiry.

Near Red Bluff there is a shoal in Waccamaw River at the head of tide; it is about 200 yards over, with a depth of but 1½ foot at the lowest stages of the water. The canal would debouché below this; hence to Winyaw Bay and out to sea the only obstruction to the navigation of the river by steamboats lies 5 miles below Conwaysboro, at Cox's Shoal, where, at the lowest water, there is a depth of 6 feet. The length of the obstruction does not exceed 150 yards. With this exception, there is in the Waccamaw River, below the proposed termination of the canal, at all times a depth of not less than 8 feet of water, with a bold navigation, the river making good reaches, except at the "Wild Horse," about seven miles below the Red Bluff, where, for a mile and a half, it is very rapid and crooked; and again, about a mile below Conwaysboro', where the river, for about 200 yards, is also rapid and crooked, although deep.

Between Winyaw Bay and Charleston we have done nothing, except to reconnoiter the country for the purpose of becoming acquainted with the general character of the ground and with the routes which may require to be surveyed.

From Winyaw Bay there is a passage to sea over Georgetown Bar, with a depth of 7½ feet at low-water. This bar lies far out at sea; the channel is very crooked and difficult of navigation; and the depth of water is represented to be decreasing. A project to connect Winyaw Bay with North Pedee by a canal has been undertaken and partly executed. It is probable that the steamboat-line might follow this route to the Pedee, thence to Charleston. Two lines, at least, ought to be surveyed; the one lying near the seaboard would avail itself of the chain of natural navigation now used occasionally by the smaller craft proceeding to and from Charleston, wherever such natural navigation might be found advantageously in the line of improvement; the other route, lying farther inland, might depart from the Pedee, and, following the best ground, which will probably be found upon a very direct course to deep water on Wando River, a branch of the Cooper River, on which is Charleston. The length of canal from Winyaw Bay to Charleston would not probably exceed 45 miles. The ground it would occupy is but a few feet above the tide, and it would not, it is believed, require in any place a greater depth of cutting to tide-water than 8 feet. It would therefore be a thorough cut, and would require none other than guard and regulating locks.

I annex a schedule of maps, charts, and profiles of the surveys already executed under your orders of the 28th March, 1837. I purpose making a general map, also, to exhibit in one view the surveys which have been done by the Department near the coast of North and South Carolina. The details of the plans for improving the sounds, so far as we have the materials for so doing, as well as the calculations of the cost of the improvements, will be undertaken, now or at the conclusion of all the surveys, to accompany the final report, as may be required by your orders.

Very respectfully, I have the honor to be, sir, your obedient servant,

JAMES KEARNEY,
Lieutenant-Colonel Topographical Engineers.

Lieut. Col. J. J. ABERT,
Commanding Topographical Engineers, U. S. A.

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LETTER OF HON. SECRETARY OF WAR TO HON. C. SHEPARD.

CORE SOUND CHANNEL.

DEPARTMENT OF WAR, *March* 14, 1838.

SIR: I transmit a report from the officer in charge of the Bureau of Topographical Engineers, in reply to your letter of the 24th February.

From this it appears that the channel over the bar in Core Sound as proposed by the existing act of Congress, to be 50 yards wide and 7 feet deep, will probably cost $80,000; and that one of the same depth, but 250 yards wide, which would constitute a beating-channel and be adapted to meet a presumed and great increase of commerce in that direction, would probably cost about $300,000.

As improvements of this kind are somewhat experimental and as the smaller channel is adequate to the present commerce and sufficiently large to prove both the practicability and durability of the plan, I feel disposed to recommend that our efforts should be confined in the first instance to a channel of the dimensions already prescribed by law.

Very respectfully, your most obedient servant,

J. R. POINSETT.

Hon. C. SHEPARD,
House of Representatives.

LETTER OF CHIEF OF TOPOGRAPHICAL BUREAU.

BUREAU OF TOPOGRAPHICAL ENGINEERS,
Washington, March 10, 1838.

SIR: In reference to the letter of the 24th ultimo, from the honorable Mr. Shepard and others, I have to report, that the survey having been committed to Lieutenant-Colonel Kearney, he has been called upon for information, and I have the honor of submitting to your consideration the following copy of his remarks:

"As stated in the letter addressed to the Secretary of War by Messrs. Shepard, Stanly, and other members of Congress from North Carolina, I think most favorably of the importance of Core Sound to that State, and to the United States, and am clearly of opinion that its channel ought to be improved and to an extent beyond that contemplated by the act to which those gentlemen refer in their letter of the 24th of February.

"The coast between Beaufort, N. C., and the Chesapeake Bay for a length of 220 or 230 miles, is nearly, and in a few years will be quite, destitute of inlets capable of admitting even the smaller class of coasters. The closing of those which formerly existed—and there have been at least as many as ten or fifteen—has been steadily progressive. In my opinion—and it has been long and deliberately formed, and frequently expressed—the maintenance of a direct navigable communication between either Albemarle or Pamplico Sounds and the ocean is impracticable. I purpose, in my final report, to attempt the demonstration of this proposition, and I think I will be able to show that Ocracoke, the only inlet now capable of admitting the passage of coasters, will probably also close in a few years. The draught of water into the sound has been reduced to 6½ feet at ordinary high tides, notwithstanding the efforts of the Government to resist the encroachment of the sand upon it. By the storms of August, September, and October last, these efforts were paralyzed, and the hope of improving the inlet was abandoned.

"Assuming the impracticability of re-opening and maintaining a communication between Albemarle or Pamplico Sounds, at any point upon the coast between Cape Henry and Cape Lookout, we have only left for the trade of those sounds, and of Chowan, Roanoke, Tar, Neuse, and other rivers, their tributaries, an opening to the north by the Dismal Swamp Canal, and to the south by Beaufort Harbor, at Old Topsail Inlet. Between Pamplico Sound and Beaufort (as stated by these gentlemen) intervenes Core Sound, which is between 38 and 39 miles long, and in which are several shoals, some having little more than 4 feet of water upon them at times of very low tides.

"Beaufort, since the settlement of the country, has never had less than 15 or 16 feet on the bar of its inlet at high tides. It has now perhaps 23 feet at high-tide; certainly it has nearly that depth, and there are a few bars to the southward of it with more. At low-water it has 16½ feet. A navigable communication for coasting-vessels would, therefore, open for the trade of a large part of North Carolina, at least one of the best, and, taking the depth of water at low tides, the character of the bar, and the safety of the coast near it into consideration, perhaps the best, Atlantic harbor south of the Chesapeake Bay.

"Several routes have been proposed, some of them have been surveyed, and one of

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em has been attempted, by which to connect the trade of the sounds herein mened with Beaufort. It does not yet appear that any one of them combines as many vantages as that by Core Sound, or that, if they were effected, the improvement of is sound should therefore be neglected.

'The following is an extract of a letter, received since this report was first printed, m a merchant of New Berne, whose testimony is worthy of confidence. It is not imbable that the statement referred to in it may be correct, although the depth of ter is much more than was found by the engineer who examined the bar during the nth of June or July, for it is well known that the gales of the summer and autumn the past year greatly changed the position and depth of some of the inlets lying imdiately west of Beaufort, and it had been already ascertained that their force and ct were strikingly manifested upon Bogue Banks, which form the western side of inlet.

"'My house is now loading the fine ship Napoleon, at Beaufort, 538 tons. She aws 18 feet when loaded. The captain told me he sounded on the bar, and could not less than 24 feet at high-water. She is bound to Liverpool, and I have her cargo there, carried through Core Sound from New Berne. I could have come at one-half expense if the water had not been so shallow.'

"The act of Congress to which reference has been made proposes a depth of 7 feet low-water, and a breadth of 50 yards, for the dimensions of the improved chanl. The depth is, perhaps, as great as could be attained within the limits of any appropriation of money which could reasonably be expected to be obtained. The breadth however, insufficient for all the objects of the improvement. Two hundred yards uld be required for a beating channel, and that breadth would also be necessary to able vessels to continue their voyage during night as well as day.

"The surveys of last year are in a state to enable me to frame a project for the improvement of the sound and to estimate the cost of it. I have refrained from doing is, and I had reserved it until all the surveys proposed by the act of the 3d of March t were completed, with the intention of presenting the whole of the subject of an land commerce south of the Chesapeake Bay to the Department at one view, not nceiving that I was authorized to report upon detached portions of the subject. I ve, however, considered the question of improvement of Core Sound sufficiently to able me to say, generally, that for a channell of the depth and breadth mentioned by t. Shepard, the cost would be somewhere about $80,000, and, for the one I have posed, about $300,000, exclusive of any jetties or other works which might possibly found necessary to protect the sides of the channel from abrasion, or to prevent the annel itself from shifting; but the probability of which I do not, with my present owledge of the composition of the bed of the sound, by any means anticipate if the rger plan were adopted.

"We are not dependent upon mere speculation for our opinion of the importance of is harbor; it was made manifest by the war of 1812-'13-'14, during which it became e depot of prizes for many of our cruisers, whence, by lighters, their cargoes were rwarded through the sounds, and, by the Dismal Swamp Canal, to the northern cities. bacco and other produce were sent by that route from Petersburgh to foreign marts, whenever the Chesapeake Bay was occupied by the enemy. The following exact from the books of the Treasury Department will show the importance of Beaufort arbor to commerce at that period, and its contrast with the usual transactions of the rt:

Year.	Gross revenue.	Tonnage of the port.
		Tons.
10	$522 00	929
11	2,681 00	909
12	18,116 00	1,022
13	105,214 00	1,041
14	74,774 00	1,466
15	4,809 00	1,538
16	2,358 00	1,344

"At the period we are now speaking of, the inland communication was embarrassed ot only by the extreme shoalness of Core Sound, which still continues, but the Dismal Swamp Canal had then but a depth of 18 to 20 inches, and a breadth of about 18 feet at he surface, and it was otherwise in so defective a state that the passage through it was ometimes altogether interrupted. The canal is now, or is proposed to be, — feet road by 6 to 7 feet deep. It is to be borne in mind, also, that Ocracoke had then about to 6 feet in its channels over the shoals in the bay, and that there existed a navigable ommunication between Currituck Sound and the ocean.

"I subjoin the following statements to enable you to form some estimate of the alue of the inland-trade connected with the sounds which lie between Beaufort and he Chesapeake:

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"Amount of certain articles transported through the Dismal Swamp Canal during the years 1833, 1834, 1835, and 1836.

"Quarter-casks wine	639
"Barrels spirits	13,707
"Barrels pork	5,540
"Barrels flour	30,232
"Barrels fish	24,522
"Bales cotton	24,091
"Cubic feet scantling, plank, and timber	960,672
"Staves	23,450,211
"Barrels tar	59,421
"Hogsheads sugar	890
"Hogsheads molasses	1,601
"Bushels salt	150,905
"Bushels corn	563,535
"Bushels wheat and flaxseed	31,004
"Cords wood	8,495
"Shingles	100,154,475
"Sundries	$17,800

"It should be remarked that during the year 1835 the navigation of the canal was obstructed for 10 weeks, and in 1836 it was totally suspended for 70 days.

"The accompanying statement, prepared for me by the collector at Ocracoke, shows that 1,149 vessels, averaging 100 tons each, passed through that inlet during the year ending October 1, 1836, of which 893 were bound coastwise, and 256 to foreign ports. In June last the expense of lighterage at Ocracoke was estimated at $100 per vessel.

"It is known that because of the difficulty of getting directly to sea from the northern ports of North Carolina, much produce finds its way to market, indirectly, through the three commercial cities of Virginia. I have not yet taken measures for estimating how much, nor the value of the foreign or other goods which enter the State through those cities.

"I am of opinion that the improvement of the sounds of North Carolina, as a general channel of communication for the coasting-trade, should not extend to the westward of Beaufort. These sounds are very shallow; and beyond Swansboro' they are generally filled with marshes, through which wind narrow, tortuous creeks, in which we find occasional shoals incapable of floating at low-tide a whale-boat with her crew on board. Besides which, some of them are very narrow, and the sand-banks, which separate them from the sea, are so low that they are equally exposed to the inroads of the ocean or of the enemy. It is along this line of coast that we find New River Inlet, as well as Bogue, the inlet to Whitock River, on which Swansboro' is situated.

"The remarks which the gentlemen have made respecting New River are undoubtedly very sound, while their views are limited to the existing connection of that river with the interior, and they measurably apply also to Whitock River. Should, however, a navigable canal be made uniting the waters of Neuse River with the northeast branch of Cape Fear River, (and my surveys of the past season have satisfied me of its practicability,) then the importance not only of New River and Whitock, but of Beaufort Harbor also, may be greatly enhanced by establishing a connection between them and the canal, a connection which their position in relation to it would invite, and one which might be formed at an expense much below the value of the improvement to the coasting-trade and to the general commerce of the country, especially in time of war.

"Memorandum of distances, roughly estimated in statute miles.

"Norfolk to Bogue Point, Beaufort Harbor, via the Dismal Swamp Canal and Core Sound, 206 miles.

"Norfolk, via Core Sound and Beaufort, to the main bar of Cape Fear River, 350 miles.

"Norfolk to Wilmington, via Dismal Swamp Canal, Albemarle, Croatan, and Pamplico Sounds, Neuse River, Slocum's Creek, and experimental line of canal surveyed last year, (57½ miles,) to northeast branch of Cape Fear River, and thence to Wilmington, 302 miles.

"Norfolk, via Chesapeake Bay and the ocean, to Beaufort Harbor, about 260 miles.

"An error appears to have been fallen into respecting the authority under which the surveys were made. That authority is altogether distinct from that for executing the work. But it was necessary that a survey should be made, and a plan of improvement be adopted before the work was undertaken. It so happened that the appropriation for the special work on Core Island was made before the appropriation and authority for the general survey and plans for an inland communication between the Chesapeake and Charleston. The two duties were assigned to separate branches of the service. The execution of the work on Core Sound, in the first instance, to the

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engineers of fortification, as was likewise the special survey and improvement of New River; after which, and before the engineers charged with the special improvement had commenced operations in the field, came the authority and means for making the general survey, &c., the execution of which was given in charge to the topographical engineers.

"It would seem that at New River Inlet, the obstructions have been surveyed under the authority granted for its improvement, but that Core Sound has not been, and that the work of improvement has not been commenced at either place, but that preparations have been made toward it, and that the work of Core Sound halts for lack of survey and plans.

"Both Core Sound and New River fall within the line of operations of the officer charged with investigating the general question of an inland coastwise communication to Charleston; and the sound has been surveyed, and the work has been for some time past in a state of preparation to enable him to form a general plan of improvement, and to estimate the cost of executing it, at least so far as the excavation of the channel is concerned.

"The plan of improvement which he would recommend exceeds greatly in extent and point of expense, as has been already intimated, the improvement contemplated by the act of the Twenty-fourth Congress. It is connected with a general system for the accommodation of the coasting-trade of the Union in peace, and its protection during war.

"It has been questioned by the officer in charge of the duty whether, on the one hand, his plans should be narrowed down to the limited object which the legislature were apparently contemplating at the time of the passage of the act of 1824; or, on the other hand, would he be warranted in proposing his plan, or could the Department undertake the execution, without legislative sanction of a project so far exceeding in dimensions and cost the one which the act referred to had indicated?

"Again, it was believed that the general inland coastwise navigation should abandon the sounds, and be carried inland, at least from the waters of the Neuse to those of Cape Fear River; although, apparently, the legislature deemed that it might follow the line of sounds upon the coast, from Pamlico to the vicinity of the new inlet of Cape Fear. At the same time the engineer was persuaded that Beaufort Harbor was so important to commerce, that it deserved to be made the principal inlet to the great sounds of North Carolina, and that Core Sound should be improved so as to become a most important branch of the general inland communication.

"Upon so serious a subject it was to be questioned whether the Department would be warranted in compromising the legislature. It is yet a question for the Department how far the selection of either route may compromise the execution of the other.

"The officer charged with the execution of the surveys asks the orders of the Department to report on any detached portions of the work.

"Should it, nevertheless, be deemed expedient to open the channel of Core Sound at as early a day as practicable, in anticipation of the restriction of Ocracoke Inlet, or to provide against the contingency of war, an increased appropriation ought to be asked for, so as to make the fund available for the current year amount to forty or sixty thousand dollars.

"J. KEARNEY,
"*Lieutenant-Colonel Topographical Engineers.*"

Respectfully submitted by, sir, your obedient servant,

J. J. ABERT,
Lieutenant-Colonel Topographical Engineers.

Hon. J. R. POINSETT,
Secretary of War.

2.—REMARKS AND CONDENSED HISTORICAL EXTRACTS RELATING TO CHANGES IN COAST-LINE OF NORTH CAROLINA.

"Hakluyt's collection of voyages, imprinted in London in the year 1600," giving the original report made to Sir Walter Raleigh.

First voyage was "made to the coast of America in two barks," wherein were Captaines Master Philip Amadas and Master Arthur Barlowe, who discovered part of the country now called Virginia, anno 1584. Written by one of the said captaines."

April 27.—"In the year of our redemption 1584 we departed the coast of England by way of the West Indies," and arrived on the coast of Carolina July 4, 1584. The fleet sailed along the land for 120 miles before finding an entrance. "The first that offered itself we entered, though not without some difficulty." The beach lay stretching itself to the west, which they found to be an island 20 miles long and 6 broad.

This account agrees more nearly with the coast near Ocracoke Inlet. The beach here extends nearly east and west for a short distance, although its general trend is

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southwest, and the broadest part of the "bank" is found at Cape Hatteras. At the present time this breadth is not more than 3 miles; but it seems probable, from the old maps, that at one time it was much wider. This locality is partly identified by the visit of the Indian Granginemeo, (the brother of King Wingina,) who appears to have lived at Roanoke Island. After the visit of the Indians, the account proceeds:

"Myself, with seven more men, went 20 miles up the river that runneth toward the city of Skicoak, which river they call Occam, and the *evening following* to an island which they call Roanoak, distant from the harbor by which we entered 7 leagues."

A village is mentioned on the north end of the island, where they were met by the wife of Granginemeo. I would call attention to the fact that this distance of 7 leagues cannot be reconciled with the distance of Roanoke Island from Ocracoke, or any other practicable inlet. Nor can the sound, which is subsequently called a great sea, be identified with the river Occam. But the following passage would seem to indicate that Alligator River might be the Occam of that date, for this river can, on account of its width and depth, be properly called "the great river."

The city of Pomeiock, then situated on Mattamuskeet Lake, was also near the head of the river Occam, and the nearest and most convenient route from this city to Skicoak, according to Hariot's map, would be by the channel of this river. "Beyond this island," (Roanoke,) continues the narrative, "is the main-land, and over against this island" (ought it not to be main-land?) "falleth into the spacious water" (Albemarle Sound) "the great river called Occam by the inhabitants, on which standeth a town called Pomeiock, and six days' journey from the same is situated their greatest city, called Skicoak."

This city was situated somewhere between Suffolk and Portsmouth, Va., and the most convenient and shortest route from Pomeiock would have been by the way of the Alligator River, which I suppose to be Occam. The statement of Amadas that he and seven men, after reaching the main-land opposite Ocracoke Inlet, passed "20 miles up the river that runneth toward the city of Skicoak, which river they call Occam," is not so easy of explanation. Pamplico Sound could not be mistaken for a river, as it is throughout called a great sea or sound. The most plausible explanation is that Long Shoal River was at that time connected with Alligator River. This is probable, because, at the present time, it is barely closed, and the rapid shoaling and filling of bays and channels in this locality by weeds, aquatic plants, and sediment has been often observed. The only explanation I can offer for the erroneous statement of the distance of Roanoke Island is, that the writer made no measurements, but thought that the inlet where he entered, the main where he landed, and the island formed (judging by the eye) an equilateral triangle. Seven leagues is very nearly the correct distance of the "inlet where he entered" from the main. By a natural error this distance was supposed to be the same as to the island, which they reached the "evening following."

In the History of Francis Xavier Martin, published in New Orleans in 1629, the river Occam is supposed to be identical with Pamplico Sound, but the original reports do not sustain this conjecture.

The exploring party pushed their examination toward the southern part of the sound. They visited the town of Sequotan, on Pamplica and Neuse Rivers. Here they learned that, twenty-six years previous, a ship had been cast ashore, and that the men who were saved, after remaining ten days on an "out uninhabited island called Wokokon," obtained some boats of the country, and lashing two together and making sails of their shirts, attempted to escape, but were cast ashore.

Amadas examined Albemarle Sound, and passed up the Chowan River to the Cipo and Nomopana, supposed to be the Nottoway and Meherrin, or Blackwater Rivers. On one of these was situated the great town of Chowanook.

The sounds are described generally, and the number of navigable inlets appear to have been the same as are found at the present day. "After we entered the haven," (or sound,) "we saw before us another *mighty long sea*, for there lyeth along the coast a tract of islands 200 miles in length, adjoining the ocean sea, and between the islands two or three entrances, which, when you have entered between them, (these islands being narrow for the most part, in most places 6 miles broad, in some places less, in few more, there appeareth another great sea, containing, in width, in some places 40, in some 50, in some 20 miles over, before you come to the continent, and in the inclosed sea there are about one hundred islands of divers bigness, whereof one is 16 miles long, on which we live, finding it most pleasant and fertile ground." The present Roanoke Island is but 11 miles long, but has been and is still being washed away. The washing is particularly active on the sides, or next to Roanoke and Croatan Sounds.

This expedition returned with such glowing accounts of their discoveries, that Sir Walter fitted out a second.

Second voyage.

April 9, 1585.—The second fleet of seven vessels sailed under the command of Sir Richard Greenville, (also written Grinville and Grenville,) with the intention of estab-

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lishing a permanent colony. Two of the ships were of 140 tons burden, one of 100 tons, and one of 50 tons, with two pinnaces and two small boats. Taking the West India route, they reached Wokokan June 26.

Next day the Tiger, 140 tons, is lost trying to enter the harbor.

July 3.—They send a messenger to Wingina, supposed to be with his brother on Roanoke Island.

July 6.—Two ship's officers were sent to Croatan, where two men had been left the day before.

July 11.—"The general, (Greenville,) accompanied in the tilt-boat with Master John Arundell, Master Stakely, and divers other gentlemen; Master Lane, Master Candish, Master Hariot, (the astronomer,) and twenty others in two pinesses; Captain Amadas, Captain Clarke, with ten others in a ship's boat; Thomas Brookes and John White in another boat, (35 to 40 in all,) passed over the water from Wokokon to the main-land, victualled for eight days"—in which expedition they discover the "town of Pomeiock," (near Lake Mattamuskeet,) "Aquascogoc, Secotan, and also the great lake, Paquique, (or Mattamuskeet,) with divers other places, and returned with that discovery to our fleet." From the statement, the fleet, after the loss of the Tiger, appears to have anchored outside. The course of the expedition was directly across the sound from Wokokon (Ocracoke) to the main near Pomeiock, (on the bank of Mattamuskeet;) then they visited Pungo, Pamplico, and Neuse Rivers.

The 12th, 13th, 14th, 15th, and 16th of July were spent in revisiting these same localities.

In order to identify the points above mentioned, the reader must refer to Hariot's maps, which have been mentioned before.

July 21.—The fleet weigh anchor for Hatorask, (not Cape Hatteras, but some point at or near Oregon Inlet.)

July 27.—The fleet anchored at Hatorask. It must, therefore, have taken six days for the fleet to have beat around Cape Hatteras.

July 29.—Grangino, brother of King Wingina, came on board the Admiral.

August 25.—General Sir Richard Greenville weighed anchor, after leaving Phillip Amadas, Arthur Hariot, and others, numbering at least 107 individuals, under Ralph Lane as governor.

The further account of the colony is found in the report of Governor Lane. Lane sent out exploring parties. These expeditions were made in a four-oared boat, capable of carrying fifteen men and seven days' provisions.

"To the northwest," says Lane, "the farthest place of discovery was Chawanook, distant from Roanoke (Island) 130 miles." After mentioning Chesapeake Bay, the narrative continues: "Our passage lyeth through a broad sound, (Albemarle,) but all *fresh water* and the channel of great depth, navigable for good shipping, but out of the channel full of shoals." The town of Chawanook, which was near the Chowan River, could, he states, put 700 men in the field.

He discovers the rapid rivers of Moratuc and Marattico, outlets of the Roanoke, which empty into the sound of Weopomeick or Albemarle.

About this time thefts on the part of the Indians, wrongs and suspicions on both sides, led to unfriendly feeling between the whites and the natives. A fight occurred, and Wingina was killed.

In June, 1558, Captain Stafford reported that "he had discovered a fleet of 23 sail off the coast." It proved to be that of the brave and skillful navigator, Sir Francis Drake, who, after harrying the Spanish Indies, was returning to England.

This able commander at once comprehended the necessities of his countrymen, and "made bountiful and honorable offers," "not only of victuals, provisions, munitions, clothing, but also of barks, pinesses, and boats, they also to be manned and furnished to my contentation." He first placed at Lane's disposal a 70-ton ship, fully provisioned and equipped, but a storm arising she was blown to sea. He then "appointed another of 170 tons," but the master "*would not, for anything, undertake to bring her into the harbor.*"

Much discontent and discussion now arose, and the colonists petitioned Lane to take them back to England. Sir Francis Drake acceding, the colony returned, reaching England July, 1586, after a passage of thirty days. Lane had remained in North Carolina from the 17th of August, 1585, to the 18th of June, 1586.

Third voyage, 1586.

This voyage was made for the relief of the colony sent by Sir Walter in 1585, who was ignorant of their departure. A ship of 100 tons was first sent, and fourteen or fifteen days later Sir Richard Greenville sailed with three ships. But the colony, as has been related, had left Carolina, and were already near their native country. Sir Richard, after a short stay, concluded to leave 15 men on Roanoke Island and to return.

Fourth voyage.

"Sir Walter again fitted out three ships, one of 120 tons, one fly-boat and pinesses and prepared a second colony of 150 men, to be sent under the charge of John White,

whom he appointed governor, and also appointed unto him 12 assistants, and incorporated them under the name of governor and assistants of the city of Raleigh, in Virginia."

July 16, the fleet made Cape Fear, which the pilot mistook for Croatan. (See Hariot's map.)

July 20, they reached Hatorask, (Oregon Inlet.) The governor, with 40 men, prepared "to pass up the Roanoke Island forthwith," hoping to find the 15 men who had been left the previous year by Sir Richard Greenville. On inquiry of the Croatan Indians they learned that the 15 Englishmen had been set on and slain by 30 of the men of Secota, Aguscogoc, and Dasamohquepenc, living between the mouth of Alligator River and Pungo River.

To revenge this act they make a night attack under the guidance of Manteo, (an Indian,) and slaughter by mistake some friendly Indians.

"On the 21st of August, as the Lyon, 100 tons, and the fly-boat were almost ready to depart, there arose such a tempest from the northeast that our admiral, then riding out of the harbor, was forced to cut his cable and put to sea, where he lay beating off and on for six days."

In the mean time, Governor White, being earnestly entreated by the colonists to return, departed from Roanoke Island "the seven and twentieth day of August, in the morning, and the same day, at midnight, came on board the fly-boat, which had already weighed anchor, and rode without the barrier, the admiral riding by them, who but the same morning was newly come thereto again."

If the fleet were at that time off Oregon Inlet, the colonists would have required the time mentioned to have rowed and beat under sail from the island to the anchorage. The same day, August 21, they set sail for England. The report closes with a list of the colonists, 127 in all, among whom were 17 women, 9 boys, and 2 children, the latter born in North Carolina.

On the 22d of April, 1588, Governor White again sailed for America, but while undertaking a little side enterprise of his own against the Spanish commerce, he was himself captured.

Fifth voyage.

On the 20th of March, 1590, Sir Walter sent three ships under Governor White, who, as usual, took the southern route near the West Indies, and came to anchor near a narrow island supposed to be Wokokon.

August 3.—They found themselves off the coast, "in latitude 34," near Cape Fear.

August 19.—"Anchor in 9 fathoms water in 35 degrees of latitude, near a long, narrow island west of Wokokon. Between the main (as we supposed) and this island is but one mile over, and 3 or 4 feet deep in most places." This description agrees with Core Sound, but the latitude is near 34° 45′ rather than 35°.

August 12.—"Anchor at northeast end of Croatoan (Cape Hatteras) by reason of a breach (channel through the Hatteras Shoals) which we perceived to lie out 2 or 3 leagues in the sea, where we rode all night," "the ship riding in 5 fathoms, at a ship's length it was 4½, then deepening or shoaling for 2 miles, so that sometimes we found 5 fathoms and by and by 7, and within two casts of the lead 9 and then 8 fathoms; next cast 5 and then 6, next 4 and then 9 again and deepening, but 3 fathoms was the last at 2 leagues from the shore." "This breach lyeth near the northeast point of Croatoan Island, whereat goeth a fret into the inner waters, which part the islands (barrier reefs) from the main land."

August 15.—Anchor at Hatorask.

August 16.—They send a boat on shore—latitude 36½°.

August 17.—They prepared to "go up to Roanoke Island." "The wind blowing northeast, the sea broke extremely on the bar," so that the admiral's boat was nearly swamped while passing in at the inlet, and the second boat was upset, and 7 out of 11 men were drowned. After this accident two boats were again sent out with 19 men for Hatorask. They anchored that night at Roanoke Island and landed the next morning. Here they found the recent foot-prints of savages. "As we entered up a sandy bank, upon a tree near the very brow thereof was curiously carved in fair Romaine letters 'Cro,' which letters presently we knew to signify the place where I should find the planters seated, according to a secret token agreed upon between these men and me at my last departure from them, which was that, in any ways, they should not fail to write or carve on trees, post, or dores the name of the place where they should be seated, for at my coming away they were proposing to remove into the main; therefore, at my departure in 1587, I willed that if they should happen to be distressed, that they should carve over the letters or name a cross." "Having well considered this, we pass toward the place where they were left in sundry houses, but we found the houses taken down and the place strongly inclosed with a high pallasade of trees; on the chief tree or post on the right of the entrance had the bark taken off, and 5 feet from the ground, in fair capital letters, was engraven 'Croatan,' without cross or sign of distress." Here also they found "bars of iron, pigges of lead, and iron tools, over-

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grown with weeds and grass." Not far off they "find divers chests broken up," and in the end of a trench, made by Captain Amadas, five chests were found, three of which White recognized as his own, also some books torn from their covers, and the "frames of some of my pictures and maps, and my armor almost eaten through with rust. This could be no other than the deed of the savages, our enemies, the Dasamaqueheuk."

While looking for water a storm arose, which obliged the men to leave the casks on the island. The wind increasing at night, they double their anchors and cables. The next day they weigh anchor for Croatan, (now Ocracoke,) but before leaving came near grounding at Kendrick's Mount.

From the above account of the fifth voyage it would seem that the fleet, after dispatching the two boats through Oregon Inlet, (Hatorask,) had moved down the coast to the safer anchorage near Croatan or Cape Hatteras.

The latitude of the breach out at sea, which they so carefully sounded, would place it near Wimble's Shoals, but the description proves that this must be an error, the latitude being 25′ too far north.

The latitude of Hatorask, the description of which corresponds with Oregon Inlet, is given as in 36½ degrees by Governor White, but this would place the inlet near Trinity Harbor, an impassable inlet north of Roanoke Island, according to Hariot's map. It is therefore necessary to suppose an error of 33′ in this latitude in order to explain the discrepancies.

It will be seen from the historical extracts of this note that Sir Walter Raleigh never visited the coast of Carolina, and that one of his fleets entered Ocracoke, the others anchoring off Hatteras or Oregon Inlets until they disembarked the explorers or colonists.

Roanoke Inlet does not appear on any of the maps until 1708. After that date it assumes importance on the maps. But I am inclined to think that, as this part of the coast ceased to be visited at this date, the depth of water on the bars of many of the inlets was greatly exaggerated.

All the labor, suffering, bravery, and endurance manifested on these expeditions proved ineffective in establishing a colony. In 1603 there was not a single individual left on the main. Sir Walter Raleigh, who had so liberally supplied the means, was beheaded in 1618.

About the period of the Revolution the maps of our coast, published by the English government, began to assume greater accuracy, but it was not until the charts of the United States Coast Survey were published that any accurate representation of our harbors and coast-lines could be obtained.

3.—LETTER OF PRESIDENT OF THE ALBEMARLE AND CHESAPEAKE CANAL COMPANY.

OFFICE OF THE ALBEMARLE AND CHESAPEAKE CANAL COMPANY,
Norfolk, Va., July 2, 1875.

SIR: The southern branch of the Elizabeth River, which affords navigation from the city of Norfolk to the Albemarle and Chesapeake Canal, having been placed under your direction, it affords me great pleasure to state that the improvements suggested by Col. William P. Craighill, United States Engineers, and partially executed under his direction, together with those subsequently designed and executed by you, have greatly improved the natural channel.

Steamers and sail-vessels bound to North Carolina and parts farther south may now leave Norfolk at any state of the tide and reach the canal without delay. In my letter to Colonel Craighill, dated July 25, 1874, I expressed the hope that Congress would recognize the importance of an inland water-route from the New England States to Florida, and perhaps to Texas; and it was with great pleasure I noticed that at its late session it provided for a survey of "a line between the Neuse and Cape Fear Rivers, in North Carolina, with a view to connect the waters of the same, and a like line with a view to connect the waters of Norfolk Harbor, in Virginia, with the waters of the Cape Fear River, at or near Wilmington, N. C." The great inland water-line from New York to North Carolina, now completed by means of the Albemarle and Chesapeake, Chesapeake and Delaware, and Delaware and Raritan Canals, is of vast importance, both in a commercial and military point of view; and to continue this line to Florida, and perhaps to Texas, at some future day, should engage the attention of the General and State governments. Nature has almost given us this line. A few short canals, and a little improvement in the natural water-courses, will give us this much-to-be-desired and safe channel. The present existing line, commencing at our great commercial emporium, is as follows:

1.—*New York to Philadelphia.*

Delaware and Raritan Canal, length 43 miles; locks, 24 feet wide and 220 feet long; navigable for vessels drawing 7 feet.

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2.—Philadelphia to Baltimore.

Chesapeake and Delaware Canal, length 14 miles; locks, 24 feet wide and 220 feet long; navigable to vessels drawing 10 feet.

3.—Baltimore to North Carolina.

Two routes. 1. Dismal Swamp Canal, length, 29 miles; five locks 17 feet wide and 94 feet long; navigable for vessels drawing 4 feet.

2. Albemarle and Chesapeake Canal, length 14 miles; one lock, 40 feet wide and 220 feet long; navigable for vessels drawing 7 feet, and miter-sill of lock placed for 10 feet.

From North Carolina southward the line of inland navigation has not been determined. A party of engineers, under your direction, have gone to explore the country, and I trust will find a suitable route. The Dismal Swamp Canal was built at an early period of our history, and more in reference to procuring lumber and shingles from the Great Dismal Swamp than for the purposes of navigation; in fact, its present charter was procured from the States of North Carolina and Virginia as early as 1786, and its locks constructed of wood, and affording navigation only for lighters. About the year 1818, Congress having aided the company by a liberal subscription to its stock, the canal was enlarged to its present capacity, and stone locks substituted for those of wood. Since the opening of the Albemarle and Chesapeake Canal, with its great stone lock, enlarged canal, and inexhaustible supply of water, *constructed especially for the use of steam*, the trade that formerly sought a market through the Dismal Swamp Canal has been diverted through the Albemarle and Chesapeake Canal, as will more fully appear by reference to the last annual reports of the two companies. The Albemarle and Chesapeake Canal has *no tow-path*, steam being exclusively used in towing and transportation. During the fiscal year ending September 30, 1874, the following vessels passed through the Albemarle and Chesapeake Canal, viz: Steamers, 2,214; schooners, 1,607; sloops, 654; barges, 338; lighters, 937; boats, 411; rafts, 122; total, 6,283.

For the nine months ending June 30, 1875, steamers, 1,885; schooners, 1,368; sloops, 554; barges, 246; boats, 182; rafts, 54; lighters, 539; total, 4,828.

Respectfully, your obedient servant,

MARSHALL PARKS,
President Albemarle and Chesapeake Canal Company.

Mr. S. T. ABERT,
United States Civil Engineer.

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4. LETTER FROM HON. WM. J. M'ALPINE, CIVIL ENGINEER, ON THE CAPACITY OF THE ALBEMARLE AND CHESAPEAKE CANAL FOR TONNAGE.

ALBANY, *February* 25, 1871.

DEAR SIR: You have requested from me a statement of the capacity of your canal, and as compared with that of the New York Erie Canal.

The *actual* capacity of a canal is measured by the tonnage of the boats which the locks will allow to pass, and the time required to bring the boats into, lock them through, and pass from, leaving the locks ready for the entrance of a second boat.

When the boats present themselves in regular order for alternate lockings, the capacity of a canal like yours becomes enormous.

In reply to your categorical questions, I have therefore at first to assume the above conditions.

Your lock will allow boats of a displacement which will average 200 feet long, 40 feet beam, and 6 to 7 feet draught, or about 1,500 tons, weight of boat and cargo, or of about 1,000 tons of cargo alone.

The lift of your entrance-lock varies from 1 to 4 feet—depending on the tides and the prevailing winds of the Atlantic. Six boats an hour moving in the same direction can be locked through, or ten boats an hour, if they present themselves alternately in each direction.

This would give either 240 or 144 boats per day, and allowing fifteen days in each year for obstruction by ice, &c., would show a capacity of from eighty-four to fifty million of tons annually.

The Erie Canal locks allow the passage of boats with a displacement equal to an average of 100 feet length, 17½ feet beam, and 6 feet draught, giving 327 tons of weight for the boat and cargo, or 250 tons of cargo alone.

Three hundred lockages are often made in one day with the aid of its double locks, or one lockage every five minutes through locks of 8 to 10 feet lift, which for eight months, or two hundred and thirty-three working-days, would give an annual capacity of about seventeen million of tons.

The Erie Canal is closed by ice for nearly four months in each year.

There are seasons of the working-year when the boats present themselves unequally in the opposite direction, and at others when the business does not demand the use of

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all the boats, so that even with the double locks the greatest amount of tonnage ever carried through the Erie Canal in the eight months was about six and a half million tons.

The Albemarle and Chesapeake Canal locks allow vessels of four times the tonnage of the Erie to pass, and although those larger vessels would, under different circumstances, require longer time for lockage, yet with your locks of so small lift the lockages might be made in the same time as has been found practicable on the Erie.

Hence it can be said that practically your canal has a capacity four times as great as that of the Erie, or (in twelve, instead of eight months) of thirty-nine million of tons annually.

This is (if I remember correctly) more than two hundred times as great as your present annual tonnage.

I am not advised of the use which you desire to make of this reply to your question, but as it contains a mere statement of facts, I have no objection to your using it in public or in private, as you think proper.

Very truly, yours,

WM. J. MCALPINE.

MARSHALL PARKS, Esq., *President, &c.*

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5. The following tables relate to the trade which passes annually through the Albemarle and Chesapeake Canal:

Number and class of vessels passed through the Albemarle and Chesapeake Canal from October 1, 1860, *to September* 30, 1875.

Year.	Steamers.	Schooners.	Sloops.	Barges.	Lighters.	Boats.	Rafts.	Total.
1861	671	1,139	74	153	300	179	8	2,524
1862	453	192	88	69	275	188	.....	1,265
1863	377	62	71	16	292	125	.....	943
1864	953	24	15	124	96	174	5	1,391
1865	1,300	266	190	122	79	602	3	2,563
1866	1,062	739	302	256	338	921	18	3,636
1867	1,112	907	358	313	763	761	29	4,243
1868	1,093	944	442	381	778	1,066	26	4,730
1869	1,093	752	398	297	950	1,077	36	4,603
1870	1,487	859	437	167	911	486	35	4,382
1871	1,656	944	555	183	1,030	483	49	4,900
1872	1,667	1,070	523	158	752	553	85	4,808
1873	2,075	1,390	592	225	886	460	152	5,770
1874	2,214	1,607	654	338	937	411	122	6,283
1875	2,408	1,837	722	340	697	425	73	6,502
Total	19,621	12,722	5,421	3,142	9,084	7,911	641	58,542

Report of number and class of vessels passed through the Albemarle and Chesapeake Canal from October 1, 1874, *to September* 30, 1875.

Year.	Months.	Steamers.	Schooners.	Sloops.	Barges.	Lighters.	Boats.	Rafts.	Total.
1874	October	231	131	41	40	91	26	9	569
1874	November	246	136	115	35	80	15	5	632
1874	December	222	197	88	26	75	18	6	633
1875	January	165	171	68	20	52	10	3	489
1875	February	156	113	50	17	45	16	4	401
1875	March	223	181	94	23	58	19	6	604
1875	April	233	177	85	29	49	30	3	606
1875	May	203	160	42	30	52	21	10	518
1875	June	204	107	22	28	51	26	8	446
1875	July	194	229	47	35	43	117	5	670
1875	August	168	151	46	31	46	116	8	566
1875	September	162	84	24	26	55	11	6	368
	Total	2,408	1,837	722	340	697	425	73	6,502
	North	1,202	915	360	170	347	210	73	3,277
	South	1,206	922	362	170	350	215	.....	3,225
	Total	2,408	1,837	722	340	697	425	73	6,502

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Shipments through the Albemarle and Chesapeake Canal, south, for the fiscal year ending September 30, 1875.

Year.	Months.	Barrels bread.	Barrels beef and pork.	Barrels cider and beer.	Barrels flour.	Barrels fish.	Barrels molasses.	Barrels spirits.	Barrels sugar.	Bags coffee.	Boxes soap and tallow candles.	Boxes hats and shoes.	Boxes tobacco.	Dry goods, cubic feet.	Hardware, cubic feet.	Kegs nails.	Crates ware.	Casks lime and cement.	Bushels oyster-shells.	Pounds iron.	Tons guano.	Tons ice.	Bales hay.	Sacks salt.	Bushels salt.	Barrels oil.	Bushels agricultural lime.	Passengers.
1874	October....	291	1,728	17½	5,670	76	222	400	336	219	211	661	200	4,871	367	609	40	161	8,500	11,050	¾	32½	182	1,361	600	214	11,200	260
	November.	356	828	49½	3,059	100	138	304½	167½	181½	168	234	211	1,538	169	213	18	147	5,800	6,900	1½	71	332	1,335	0	271	2,300	191
	December.	325	664	12	2,554	35	174	274	282½	282	270	192	320	7,926	155	164	7	739	2,800	7,595	1	25½	467	2,593	0	105	2,000	289
1875	January...	177	474	4	2,167	13	131	208	215	139	142	73	182	1,770	65	172	17	33	9,580	35,000	127	7	409	458	1,800	128	0	151
	February..	148	710	6	1,960	23	128	408	187½	175	159	73	195	1,301	112	182	5	54	10,200	3,100	149½	120	397	295	11,420	196	8,057	115
	March.....	130	887	6	2,614	20	334	510	221	103	147	179	257	2,952	44	215	9	98	16,000	2,650	398	396	626	380	10,725	222	1,300	159
	April.....	117	764	8	2,666	39	336	550	196	113	162	233	203	5,392	62	173	15	657	200	8,409	746	247	631	375	2,285	180	0	160
	May.....	104	720	26	3,064	51	229	298	136	96	142	133	176	1,856	48	94	14	590	5,040	3,900	73	4	787	189	200	168	0	149
	June.....	142	593	11	2,156	128	180	162	181	103	207	100	117	2,403	72	67	11	24	0	6,425	10	32	290	45	400	93	2,100	212
	July.....	123	577	18	1,750	146	180	192	173	90	110	91	62	1,504	24	72	6	157	0	5,800	8	31	246	34	0	89	1,350	139
	August....	87	856	19	2,492	25	177	150	178	101	129	29	82	1,777	0	97	0	50	400	14,900	5	17	122	137	0	81	900	138
	September.	271	693	26	2,632	117	201	304	222	154	192	329	123	4,488	8	233	41	200	1,300	28,728	0	7	62	498	0	251	5,500	153
	Totals..	2,271	9,594	203	32,775	773	2,430	3,760½	2,495½	1,756½	2,039	2,327	2,128	40,778	1,126	2,291	183	2,910	59,820	134,457	1,517½	990½	4,551	7,700	27,430	1,998	34,707	2,136

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Receipts of produce through the Albemarle and Chesapeake Canal, north, for the fiscal year ending September 30, 1875.

Year.	Months.	Bales cotton.	Barrels fish.	Barrels naval stores.	Barrels spirits turpentine.	Bushels flax-seed.	Pounds rags.	Pounds iron.	Pounds bacon.	Last-blocks.	Cords wood.	Bushels corn.	Railroad-ties.	Bushels potatoes.	Cords juniper logs.	Bushels wheat.	Bushels beans and peas.	Feet lumber.	Shingles.	Staves.	Passengers.
1874	October....	7,483	526	1,748	95	4	4,840	8,830	1,875	.....	437	1,192	6,003	8,030	303⅛	62	124	2,047,222	2,386,430	131,320	168
	November.	13,830	684	588	11	.....	5,625	18,300	5,250	1,670	303¾	23,219	3,018	8,143	368	.....	219	1,860,717	2,309,675	104,550	204
	December.	10,719	256½	759	.....	.....	3,050	8,114	9,000	3,000	242½	87,133	2,339	1,760	128½	.....	212	1,996,037	2,087,870	121,242	289
1875	January...	6,063	227	433	.....	.....	3,000	.....	10,000	4,000	166	99,581	567	1,793	64½	.....	446	1,298,227	1,661,525	123,086	225
	February..	3,438	316	758	.....	.....	4,170	.....	7,500	2,970	129½	55,425	1,756	7,933	109	.....	1,507	957,231	1,016,173	58,449	144
	March.....	2,337	611	1,995	32	.....	3,831	.....	9,300	7,500	128	43,856	537	3,604	315	.....	4,490	1,889,115	2,902,115	100,050	158
	April.....	1,701	4,054	1,713	61	.....	1,615	1,650	3,125	.....	89	30,335	3,650	3,339	263½	.....	178	1,915,361	2,652,590	81,015	192
	May.....	515	6,185	1,474	77	.....	11,250	.....	719	17,800	91½	37,813	2,574	1,983	503½	.....	347	2,589,376	3,618,560	66,079	246
	June.....	151	229	997	137	.....	5,662	56,500	2,393	8,300	119	9,011	12,405	2,493	434½	29	580	4,464,031	3,832,820	71,200	220
	July.....	36	44	1,149	231	3,683	.....	23,168	2,550	8,337	105	19,399	2,388	3,511	267	1,000	.....	3,126,366	2,780,700	93,301	238
	August....	19	5	1,108	309	4,474	.....	47,300	1,765	.....	74	26,340	362	732	362½	1,509	.....	3,097,897	2,886,300	98,068	158
	September.	1,462	86	806	197	36	7,700	32,650	1,050	.....	202½	6,612	970	3,134	302	470	.....	1,847,000	3,384,750	162,893	142
	Totals..	47,754	13,217⅛	11,202	1,140	8,197	50,743	196,512	54,527	53,577	2,007½	440,907	32,619	46,475	3,442½	3,070	8,103	27,008,580	31,519,508	1,211,253	2,384

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The following table gives the more important products of the counties bordering the sounds. It is compiled from the census-returns of 1870:

Table showing population and productions of counties in Virginia and North Carolina on and adjacent to a line to connect Norfolk, Va., and Wilmington, N. C., (ninth census.)

Name of county.	Population.	Value of farm productions.	Wheat.	Corn.	Tobacco.	Rice.	Oats.	Irish potatoes.	Sweet potatoes.	Cotton.	Wool.
			Bushels.	*Bushels.*	*Pounds.*	*Pounds.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bales.*	*Pounds.*
Norfolk, Va	46, 702	$718, 827	105	348, 821	.....	.....	2, 888	69, 212	43, 913	.....	774
Princess Anne, Va	8, 273	622, 615	2, 831	398, 105	400	.....	21, 985	19, 975	39, 416	.....	7, 105
Currituck, N. C	5, 131	411, 790	1, 345	270, 699	.....	.....	1, 150	14, 380	69, 708	64	4, 308
Camden, N. C	5, 361	337, 789	2, 823	329, 660	50	.....	10, 430	7, 186	24, 655	58	2, 845
Pasquotank, N. C	8, 131	663, 372	22, 086	434, 985	.....	.....	11, 504	7, 311	23, 937	110	1, 077
Perquimons, N. C	7, 945	534, 499	34, 232	310, 135	682	2	27, 519	3, 908	32, 851	593	1, 891
Chowan, N. C	6, 450	410, 458	9, 176	137, 647	189	33	9, 730	4, 740	41, 130	1, 331	779
Bertie, N. C	12, 950	862, 509	1, 941	300, 314	790	60	11, 522	9, 759	54, 599	5, 055	6, 284
Washington, N. C	6, 516	296, 822	2, 413	152, 038	75	13, 256	4, 104	5, 207	28, 309	1, 087	1, 738
Tyrrel, N. C	4, 173	188, 260	737	105, 308	.....	17, 894	2, 418	4, 097	22, 544	507	2, 355
Dare, N. C	2, 778	8, 100	.....	2, 425	.....	.....	15	230	3, 185	.....	.....
Hyde, N. C	6, 445	227, 614	21, 319	163, 216	100	171, 548	11, 633	1, 107	8, 923	235	2, 227
Beaufort, N. C	13, 011	496, 161	1, 987	179, 994	3, 245	59, 206	3, 674	3, 893	102, 626	1, 987	2, 501
Craven, N. C	20, 516	821, 567	3, 310	241, 034	4, 765	55, 386	5, 966	5, 254	112, 217	3, 809	4, 780
Jones, N. C	5, 002	190, 435	2, 142	96, 385	6, 030	5, 790	2, 111	1, 709	14, 139	1, 196	3, 203
Carteret, N. C	9, 010	151, 038	1, 637	32, 260	.....	210	165	60	58, 715	774	50
Onslow, N. C	7, 569	372, 019	.....	117, 420	.....	10, 590	125	2, 632	62, 186	881	3, 734
New Hanover, N. C	27, 978	634, 083	.....	133, 176	.....	398, 925	540	4, 192	94, 713	70	11, 629
Totals	203, 941	7, 967, 958	108, 084	3, 753, 622	16, 326	732, 900	127, 479	164, 852	837, 766	17, 757	57, 280

NOTE.—A large amount of tar, pitch, turpentine, and rosin, known as "naval stores," is not included in the above table.

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The two following letters, from the collectors of the ports of New Berne and Beaufort, contain some interesting statistical facts:

LETTER FROM COLLECTOR OF CUSTOMS AT NEW BERNE, N. C.

CUSTOM-HOUSE, NEW BERNE, N. C.,
Collector's Office, October 27, 1875.

SIR: In compliance with your request, I submit the following statement relative to the trade of New Berne, N. C.:

The total number of vessels entered coastwise during the year ending July 31, 1875, was, steamers 150, tonnage 35,000; sail-vessels 40, tonnage 3,890; total entrance, 38,890 tons and 190 vessels. Entrance of American vessels from foreign ports 6, tonnage 500. Clearance, domestic commerce, steamers 40, tonnage 9,765; sail-vessels 12, tonnage 1,200. Foreign clearance, American vessels 7, tonnage 687. The greatest draught of water required by any of the above vessels is 8½ feet. These statistics have been compiled from the records of this office, and one hundred per centum may be added to the total tonnage for the reason that all vessels engaged in the coastwise trade, north of the southern limits of Georgia, are not required by law to enter and clear at the custom-house; hence we have no official record of this class. There has been considerable decline in the tonnage as compared with former years, owing to the fact that the large steamers formerly plying between this port and Philadelphia and New York have been withdrawn. No vessels drawing over 8½ feet can cross the bar at the "Swash," Hatteras Inlet, (inside,) and it frequently occurs that vessels passing in the inlet with this draught are detained on the "Swash." The obstruction known as the "Blockade," caused by sunken vessels placed there during the war, leaving only a narrow channel, and distant from New Berne about three miles, is the most serious impediment to the navigation of the river in approaching and leaving New Berne. This statement will apply to Washington, N. C.

I am, sir, very respectfully, your obedient servant,

T. A. HENRY, *Collector.*

Mr. S. T. ABERT,
United States Civil Engineer.

LETTER FROM COLLECTOR OF CUSTOMS AT BEAUFORT, N. C.

BEAUFORT, N. C., *September 2*, 1875.

SIR: In reply to your inquiry, I submit the most reliable information in regard to the trade of this place I can obtain.

Coming through Bogue Sound to Beaufort Harbor, 1,000 bales cotton, 4,000 barrels turpentine, 2,000 barrels spirits turpentine and resin; other products, including salt fish, $25,000.

Coming through Core Sound to Beaufort Harbor, bound for this place, Wilmington, and other ports, 150,000 bushels corn.

Sent through Core Sound from Beaufort, 5,000 barrels salt fish, 20,000 bushels oysters, 10,000 bushels potatoes.

Brought to Beaufort for sale and shipment, otherwise than through the sound, 500 bales cotton; other produce, $50,000.

The total resources of the county are about 2,000 bales cotton, 20,000 barrels fish; other produce, $100,000.

The depth of water on the bar is 16 feet at high-water, 12 feet at low-water, and 30 feet after crossing the bar. I will be pleased to give you any other information in my power that you may desire.

I am, sir, very respectfully, &c.,

A. C. DAVIS, *Collector.*

Mr. S. T. ABERT,
United States Civil Engineer

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APPENDIX H.

ANNUAL REPORT OF LIEUTENANT-COLONEL Q. A. GILLMORE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
New York, July 14, 1876.

GENERAL: I have the honor to submit herewith the annual reports for the fiscal year ending June 30, 1876, upon the works of river and harbor improvement under my charge.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Col. of Engineers, Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

H 1.

CHARLESTON HARBOR, SOUTH CAROLINA.

During the fiscal year ending June 30, 1876, the sum of $10,000, appropriated by the act of Congress approved March 3, 1875, together with the balance of the former appropriations available at the close of the fiscal year ending June 30, 1875, has been expended in completing the removal of the outer end of "Bowman's" Jetty to a low-water depth of 16½ feet, so as to give a channel of that depth and a width of nearly 300 feet between the end of the shortened jetty and the nearest point of Drunken Dick Shoal, and also in dredging in Beach Channel with the United States dredging-steamer Henry Burden. A gap or depression in the shore end of the jetty, through which the tide ebbed and flowed near high-water, thus wearing away the beach, was also permanently closed to high-water mark of spring-tides.

The engagement of Mr. Griffen under special authority of the Chief of Engineers, dated March 8, 1875, was continued until August 2, at which time it was estimated that the completion of the contracts existing at the beginning of the fiscal year with Mr. Maillefert and Mr. Symons would give the required depth of 16½ feet low-water sounding over the entire length of the jetty to be reduced. Mr. Griffen under this agreement removed 241 cubic yards of stone during the past fiscal year, and piled it on the outer end of the jetty.

Under the contract entered into with Mr. B. Maillefert May 1, 1874, for the removal of 2,000 cubic yards, there were removed from the outer end of the jetty 422 cubic yards, which completed this contract.

Mr. Symons's contract for the removal of 2,500 cubic yards was completed in March, 1876, with the removal of 2,004 cubic yards.

Total number of cubic yards of stone removed by the three contractors during the fiscal year was 2,667, of which 663 cubic yards were spiled on the shore end of the jetty and 2,004 deposited in deep water.

The dredging of this channel by the dredging-steamer Henry Burden was commenced in September and continued through October. During

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this time 9,632 cubic yards of sand were removed and the channel made 200 feet wide, 13 feet deep.

Since the completion of the removal of the outer end of the jetty, that portion of the channel that was before deep has shoaled considerably. Whether this is permanent or not I am unable to state, but it is proposed to remove this by dredging, $10,000 having been asked for this purpose in my last annual report.

No further appropriation is now recommended for continuing this work beyond the amount above specified.

In my last annual report the fact was mentioned that the municipal authorities of the city of Charleston had undertaken the improvement of the Pumpkin Hill Channel over the main bar opposite the south end of Morris Island, under a contract with Mr. Benjamin Maillefert. This channel was inspected in January last by my assistant, Captain Post, Corps of Engineers, at the request of Mr. S. T. Tupper, president of the chamber of commerce of the city. He reported that there was no perceptible improvement in this channel, notwithstanding Mr. Maillefert's dredge-steamer had then been at work nearly a year.

During the last week of May and the first week of June, 1876, a limited number of current-observations were made in Beach Channel, for the purpose of obtaining somewhat more precise data concerning the relative volumes of ebb and flood through said channel. It is not deemed necessary at the present time to enter into a detailed account of the operations and subsequent calculations; only the general results will be given.

The observations were chiefly made on two profiles, taken as nearly as practicable normally to the direction of currents. One, which may be called Profile I, was situated about 500 yards east of "Bowman's" Jetty, extending from Sullivan's Island across the channel to Drunken Dick Shoal, a length of about 370 yards. The greatest low-water depth found here was 15 feet. During the observations at this profile there was a moderate southeast breeze blowing. It was found that during a complete flood-tide a volume of 483,869,886 cubic feet passed this profile, while during a complete ebb-tide a volume of 226,389,802 cubic feet went out. That is to say, for every 100 cubic feet of flood flowing in through that part of the channel, only 46.8 cubic feet pass out at ebb-tide.

Another, Profile II, was selected a little further down, about 930 yards east of the jetty. It did not quite reach the breakers of Drunken Dick Shoal, its length being about 440 yards. During the observations at this profile there was almost a calm. The greatest depth was found to be 18 feet at mean low-water. During a complete flood-tide 652,132,460 cubic feet passed this profile; during ebb, 341,891,414 cubic feet. For every 100 cubic feet of flood going in, there are consequently about 52½ cubic feet flowing out at ebb, the balance of the flood finding other outlets at ebb-tide. The somewhat larger percentage of ebb that passed out at Profile II may be attributed to and accounted for by the differences in the meteorological influences prevailing at the two profiles.

The results in both cases certainly furnish sufficient proof of the flood-tide character of Beach Channel, to which reference has been made in my former reports.

Money statement.

Amount available July 1, 1875	$24,991 70
Amount expended during fiscal year ending June 30, 1876	23,982 90
Amount available July 1, 1876, including $1,000 due on contracts	1,008 80
Amount appropriated by act approved August 14, 1876	10,000 00

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H 2.

SAVANNAH RIVER AND HARBOR, GEORGIA.

During the fiscal year ending June 30, 1876, the sum of $70,000 appropriated by the act of Congress approved March 3, 1875, has been expended in continuing the project forwarded August 28, 1873, with my annual report for the previous fiscal year. Total expenditures up to July 1, 1876, chargeable to that project, $117,113.19. The operations of the year just closed were as follows:

1. The partial construction of a temporary dam from the lower end of Argyle Island at the Cross-Tides to Hutchinson's Island, for the purpose of increasing the ebb-flow through Front River.
2. The deepening of the water-way between King's and Hutchinson's Islands, in order to aid the ebb-flow into Front River.
3. The widening and deepening of the channel through Garden Bank, in front of the city.
4. The opening of the new channel near the south bank of the river through the shoal just south of Fig Island.
5. The enlarging of the channel northeast of Fort Pulaski with the United States dredging-steamer Henry Burden.

In my annual report of last year it was proposed to construct a jetty about 450 yards long from the lower end of Argyle Island at the Cross-Tides, to increase the flow through Front River on the ebb. It was feared, however, that the jetty, if constructed, would give only temporary results, the effect lasting only until the scour around the end of it should be sufficient to restore the present area of its cross-section.

For this reason a temporary dam was suggested as preferable to the contemplated jetty, and authority was granted for this change in a letter of the Chief of Engineers dated October 21, 1875. This dam was to consist of two rows of piles braced together, the openings between the front row being closed by sliding shutters, which were to be adjusted so as to give the requisite increased flow on the ebb down the Front River by the backing up of a sufficient amount of the water flowing through the Cross-Tides. The piling was to extend entirely across the stream, but it was intended to leave an opening of sufficient width in the dam to allow the rice-flats of the planters in the immediate vicinity to pass back and forth. This opening it was thought would accommodate all the vessels navigating this stream.

This dam was commenced in February and the work was continued until May 13, and the dam about half completed. On this date the work was suspended, in compliance with a temporary injunction granted by the Supreme Court of the United States. The objections raised to the construction of this dam, with my report thereon, are given in my letter to the Chief of Engineers March 30, 1876. It is herewith annexed.

By advertisement dated May 20, 1875, proposals were invited for dredging at different points on the Savannah River to the aggregate amount of 179,000 to 210,000 cubic yards, at the localities named below:

First section: Abreast of Elba Island.
Second section: Between Fig Island and Fort Jackson.
Third section: Garden Bank, opposite Savannah City.
Fourth section: About 4 miles above Savannah, between Hutchinson's and King's Islands.

The following were the bids received:

City of Savannah, E. C. Anderson, mayor:
Entire work, per cubic yard..... 30 cents

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W. W. Laman, New York:

Entire work, per cubic yard ..... 24 cents.

American Dredging Company, Philadelphia, Pa.:

First section, per cubic yard ..... 26 cents.
Second section, per cubic yard ..... 24 cents.
Third section, per cubic yard ..... 25 cents.
Fourth section, per cubic yard ..... 30 cents.

Mr. Laman was the lowest bidder, but, being unable to procure the necessary dredges, withdrew his proposal on the agreement of the American Dredging Company to contract for the whole work at 24 cents per cubic yard.

The following is the width and depth of channel obtained at each of the above-named places:

At the shoal northeast of Fort Pulaski 18,349 cubic yards were removed by the United States dredging-steamer Henry Burden. This channel is now 175 feet wide and 14½ feet deep at mean low-water, and between the 13-foot curves is 250 feet wide. There is a slight indication of shoaling near the first or inner buoy, but it is doubtful if this will be permanent.

Abreast of Elba Island no work was done under the contract made, the funds on hand not being sufficient for that purpose. This channel shows a slight indication of filling up.

At the new channel at the "Wrecks," or the shoal between Fig Island and Fort Jackson, 189,348 cubic yards have been removed, 133,119 by the American Dredging Company and 56,229 by the United States dredging-steamer Henry Burden. The channel established through this shoal is 100 feet wide and 10 feet deep at mean low-water. This channel being in the direction of the axis of the river, a very strong current ebbs and flows through it, which not only tends to keep it open, but has also increased its depth and width by scouring. The old channel at this point has continued filling up until it is now only 60 feet wide and 10½ feet deep. This latter it is proposed to abandon as soon as the former is of sufficient depth and width to accommodate all the shipping of the port.

At Garden Bank, opposite the city of Savannah, 7,995 cubic yards were removed, and the channel there is now 140 feet wide and 14 feet deep at mean low-water.

Between King's and Hutchinson's Islands 9,850 cubic yards were removed, and the water-way increased by opening a channel 40 feet wide and 6 feet deep.

The other channels which have been dredged during previous fiscal years, that at the head of Elba Island and opposite Long Island were sounded out by the inspector of dredging in June last, who reports an increase of depth in the former, owing to the scour of the tide through it. The latter channel, being where the fresh and salt water meet in the ebb and flow of the tide, is filling up gradually, owing to the causes given in my last annual report. Additional data have been obtained which furnish further proof that the shoaling is due to these causes in this channel, and also that the channel abreast of Elba Island is perhaps affected by them.

WORK CONTEMPLATED DURING THE PRESENT FISCAL YEAR.

It is proposed during the present fiscal year, in the event of an adequate appropriation being made—

1st. To complete the temporary dam that has already been commenced

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at the Cross-Tides, should the temporary injunction that now restrains the continuance of it be removed.

2d. To increase the dimensions of the new channel at the "Wrecks" to 150 feet wide and 14½ feet deep, low-water soundings. The widening of this channel will render it necessary to remove one crib from its south and one wreck from its north side, in order to obtain a free water-way of the increased width. Should other wrecks or cribs be found while obtaining this that will obstruct the new channel, it is proposed to remove them also.

3d. To increase the channel-way abreast of Elba Island and possibly that opposite Long Island, should the shoaling continue so as to render it necessary.

4th. To commence the removal of Kinsey's Point opposite the city, and continue the amended line of bulk-heads in the approved project.

The estimated cost of the project for the improvement of the Savannah River and Harbor submitted August 28, 1873, was $481,320.

The following is the detailed estimate:

1. For closing Cross-Tides by a crib-dam, with opening for small vessels, protected by riprap apron	$29,500
2. For enlarging water-way opposite city front to an average of 575 feet by 15 feet, not including cost of new bulk-head	85,500
3. For dredging at "Knoll" for channel 300 feet by 15 feet	37,370
4. For dredging upper end of Long Island, 250 feet by 15 feet	37,150
5. For dredging lower end of Elba Island, 250 feet by 15½ feet	30,800
6. For dredging abreast Elba Island, 250 feet by 15½ feet	86,250
7. For dredging intermediate points, 250 feet by 15½ feet	5,000
8. For dredging upper end of Elba Island, 250 feet by 15½ feet	11,250
9. For dredging at "Wrecks" and vicinity, 250 feet by 15½ feet	15,000
10. For enlarging water-way at Fig Island	18,500
11. For dredging at Garden Bank	120,000
12. For new bulk-head just above Kinsey's Mills	5,000
	481,320

This does not include the cost of such jetties and bulk-head as may be found necessary along the flats opposite the present Fig Island bulk-head, nor generally the cost of constructing bulk-heads on the Hutchinson's Island side of the amended water-way.

There has been appropriated for this project up to June 30, 1876, $120,000, of which $117,113.19 has been expended.

Money statement.

Amount available July 1, 1875	$78,303 82
Amount expended during fiscal year ending June 30, 1876	74,532 01
Amount available July 1, 1876, including $885 due on contracts	3,771 81
Amount appropriated by act approved August 14, 1876	62,000 00
Amount (estimated) required for completion of existing project	361,320 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	200,000 00

LETTER OF LIEUT. COL. Q. A. GILLMORE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER-OFFICE,
New York, March 30, 1876.

GENERAL: I have the honor to acknowledge the receipt of the letter of the governor of South Carolina to the Hons. T. J. Robertson and S. L. Hoge, inviting attention to the "protests of the citizens of South Carolina against the erection of barriers between the Savannah, Main,

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and Back rivers, contemplated in connection with the improvement of the Savannah River," referred to me on the 25th instant for report.

A summary of all the objections set forth in the several papers submitted may be stated as follows:

1. That changes will be produced in Back River which are likely to affect the system of navigation of tide-swamp lands.

2. That there will be a probable increase of volume of water during freshets and delay in their subsiding.

3. That the navigation of the Back River will be rendered difficult by reason of sand-bars and shoals.

4. That Back River is the main channel through which the city of Charleston receives large shipments of produce, and the erection of the barrier will impair navigation in Back River and interpose increased difficulties in the transportation of many thousand bushels of rice to that city.

5. That citizens of an adjoining State will be deprived of the free use of Front River.

6. That such a work would be derogatory to the dignity of the State of South Carolina, and injurious to her rights and interests, because a violation of the pledges of the convention of 1787 between the States of South Carolina and Georgia.

It is evident from the representations made in the several communications forwarded by the governor of South Carolina that a misconception exists with respect to the character of the improvement now being carried on at the Cross-Tides, and the result which it is desired to secure by it. It is, in fact, an experimental structure of a temporary character, consisting of piles driven at stated intervals across the channel.

The piles are grooved so that planks may be slid down between them in a horizontal position, until they rest their edges on the river-bottom, the intention being to carry up the planking gradually, one plank at a time, to such height above the bottom as may be found on trial to be necessary in order to divert into Front River a portion of the ebb current which now flows down Back River, without impairing the navigation of the latter to any injurious extent.

It is not expected that the line of planks will be carried up as high by some feet as the low-water level. The flood and ebb currents can, therefore, pass freely over the work. Provision has been made for leaving an opening in the piling of dimensions amply sufficient to accommodate all the river-craft which customarily pass and repass through the Cross-Tides, so that the river-traffic of the neighborhood will experience no inconvenience.

The permanent work which it is hoped will supersede this temporary expedient in the course of a few years may be so designed that the largest class of river-craft which can ply in the Savannah River above the city of Savannah will be able to pass through an opening left in the work. All larger vessels will then, as now, enter Back River at the lower end of Fig Island.

Referring to the several objections in their regular order, it may be remarked—

1. That no injury to the method of cultivating rice by irrigation need be apprehended, for the reason that the tide in Back River will have the same height of rise and fall as at the present time. The planking between the piles will be gradually brought up to their proper height, in order that there may be no sudden changes in the stream.

2. That the danger of injury to the Back River plantations from

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freshets will not be increased by the work, but rather decreased, in consequence of the diversion into Front River of a portion of the up-river rain-fall which produces freshets in the lower reaches of the stream.

3. That no extensive shoaling in Back River need be apprehended, as the work will be kept low enough to allow the flood and ebb currents to pass over it with very little reduction of the velocity in the stream below.

4. That no injury whatever to the commerce of Charleston, or any other port or market in South Carolina, can ensue, except what results indirectly from making Savannah a better market for rice than it is at the present time. It is now the natural place of sale and shipment for all of the products of the Savannah River plantations located within 200 miles of its mouth, and if any Back River planter elects to send his rice to Charleston, over 100 miles distant, in preference to selling it in Savannah, within 3 or 4 miles of his door, he will have the same facilities for doing so that he now possesses, whether he sends it before or after it has been milled. The same is true of all the produce raised higher up the stream. If, in violation of all the laws of trade, and to the prejudice of his own interests, a producer seeks a distant market in Charleston, his vessels have an open channel with constantly-increasing depth until they reach the city of Savannah, and from that point a good ship-channel to the mouth of the stream.

5. The improvement will not deprive the citizens of an adjoining State of the free use of Front River or any other portion of the Savannah River.

6. It is submitted that the dignity of the State of South Carolina will not be put in jeopardy, nor in the least compromised by the improvement of the Savannah River at the expense and under the supervision of the United States, and would not be if the river was located entirely within the territorial limits of South Carolina. It is the undeniable law of the land that the United States may abate a public nuisance or construct works of improvement in any navigable waters of the United States, and that such waters are public highways, and as such are the property of the nation at large. The Supreme Court decided, in Gilman *vs.* Philadelphia, that—

> The power to regulate commerce comprehends the control for that purpose of all navigable waters of the United States which are accessible from a State other than those in which they lie.

The same court decided, in the case of the steamer Daniel Ball, plying on Grand River, Michigan, and libeled for not having a license under the laws of the United States, that—

> That power [the power to regulate commerce] authorizes all appropriate legislation for the protection or advancement of either interstate or foreign commerce, and for that purpose such legislation as will insure the convenient and safe navigation of all the navigable waters of the United States, &c.

The following language occurs in an opinion delivered October 19, 1853, by Hon. Caleb Cushing, Attorney-General of the United States:

> Each State has also the power to conserve the navigable waters within its jurisdiction by suitable process known to its laws. The United States may construct works for the improvement or security of a given harbor, or as a shelter for ships from storms or in time of war, and they may interpose for the conservation of said works, or to guard against any diminution of the existing advantages of a river, lake, or sea by the usurpation of individuals, or even of a sovereign State of the Union. But so, also, in my judgment, may that State itself.
>
> There is nothing in the letter of the Constitution or the spirit of the Government to forbid the State of Illinois, or the State of New York, from improving a natural harbor within its limits, blowing away rocks which impede a channel, dredging out a

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river, constructing piers, docks, breakwaters, beacons, and sea-walls, or by indictment or other process protecting the rights of riparian proprietors, or of the public at large, in its navigable waters. But the United States have a concurrent jurisdiction for any of these objects, and a jurisdiction which, in case of conflict, is paramount and exhaustive of the whole subject-matter; for otherwise a given State might do that which, while actually or in supposition beneficial to itself, would be injurious to some other State, or to citizens of the United States in general, or to the subjects of other governments in amity with the United States.

It would appear, therefore, that the improvement of the Savannah River by the United States on the authority of Congress is a legitimate exercise of conferred and authoritatively affirmed powers; that the exercise of those powers with a view of fostering commerce, increasing the revenues, promoting the greatest good of the greatest number, or for any other lawful object, cannot be derogatory to the dignity of the State of South Carolina, because the jurisdiction of the United States, for purposes of such improvements, is paramount and conclusive; and, therefore, that the convention of 1787 between the States of South Carolina and Georgia is entirely destitute of force or significance in its relations to this question and to the interstate and international interests involved in it.

In my original project for the improvement of Savannah River and harbor, submitted August 28, 1873, the question now raised is referred to in the following language:

Previous plans for the erection of a dam across the Cross-Tides water-way have contemplated the entire stoppage of flow in this direction, and have been frustrated by the not unreasonable opposition of the authorities of the State of South Carolina.

As the project now proposed makes ample provision for carrying on the ordinary trade and commerce of the locality, and as Back River throughout its entire length is at all times and tides available for such vessels as in rare and exceptionable cases cannot pass over the proposed dam at high-water, I can conceive of no well-grounded objection that can be urged against its construction.

Opposition instigated by motives of rivalry should have no weight in deciding questions involved in the improvement of a great national thoroughfare like the Savannah River.

The several papers referred to me are returned herewith.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Col. of Engineers, Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

H 3.

REPORT OF THE BOARD OF ENGINEERS ON IMPROVEMENT OF SAVANNAH HARBOR, GEORGIA.

ARMY BUILDING,
New York, June 12, 1875.

GENERAL: The undersigned, members of a board of officers of the Corps of Engineers, constituted by Paragraph I, Special Orders No. 75, dated headquarters Corps of Engineers, Washington, D. C., June 5, 1875, "to take into consideration and report upon the general subject of the improvement of Savannah River and Harbor, Georgia," have the honor to report as follows:

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REPORT.

The Board met on the 8th instant, when the presiding officer submitted the following letter of instructions from the Chief of Engineers:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., June 5, 1875.

SIR: In consideration of its importance, and of the increasing commercial interests involved, the views of the Board constituted by Paragraph I, Special Orders No. 75, current series, are desired upon the whole subject of the Savannah River improvement; as also upon the recommendations heretofore made to this office by Lieutenant-Colonel Gillmore for carrying forward this improvement to completion.

In this connection the project submitted by him to the Chief of Engineers May 13, 1875, is also submitted to the consideration of the Board, with the desire of an early report upon it.

The Board is referred to the annual report of Lieutenant-Colonel Gillmore to this office of August 28, 1873, and that officer will, in addition, furnish such information in his possession as may be desired.

By command of Brigadier-General Humphreys.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers.

Col. Z. B. TOWER,
Corps of Engineers, U. S. A.

Lieutenant-Colonel Gillmore's annual report to the Chief of Engineers of August 28, 1873, together with his project of May 13, 1875, for expending the existing appropriation during the ensuing fiscal year, and all the necessary charts and plans, were also laid before the Board.

The annual report of August 28, 1873, referred to above, embraced a project for completing the improvement of Savannah River and Harbor, which had in view the ultimate achievement of a practicable low-water ship-channel at least 15 feet in depth, by which vessels drawing 22 feet of water would be able to pass on the high-tide from Tybee Roads, where the mean rise and fall is 7 feet, to Savannah City, where the mean rise and fall at that time was only 6½ feet.

The following are the principal and essential features of this project:

First. Permanent works at the Cross-Tides, either a dam or a deflecting jetty—preferably the former—for diverting into Front River, along the city front, a portion of the water naturally flowing down Back River.

Second. The amendment of the water-way along the city front by widening it at certain points and contracting it at others, so as to give an average width of 575 feet and an average depth of 15 feet, with such additional depth, not exceeding 22 feet, at the wharves as will secure vessels against grounding while taking in or discharging their cargoes.

Third. Deepening the channel, by dredging and otherwise, over certain shoals between the city and Tybee Roads to a low-water depth varying from 15 feet upon the lower shoals to 15½ feet upon those nearest the city.

Fourth. The construction of jetties or training-walls at points where the results developed during the execution of the project, under the altered regimen of the stream, shall indicate them to be necessary to the maintenance of the established channel; or, preliminarily, at points where their effect would be to aid, or perhaps render unnecessary, the ordinary work of dredging.

The improvement of the Savannah River at the expense of the General Government was resumed during the fiscal year ending June 30, 1873, after an interruption of several years, commencing anterior to the civil war.

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The expenditures made by the engineers in charge up to the present time, including upward of $5,000 devoted to surveys, amount, in round numbers, to	$150,000
In addition to this sum, there was paid last year, under a special act of Congress, to Mr. Henry S. Welles, for removing obstructions under a contract made with the Secretary of the Treasury soon after the close of the war, the sum of	193,000
Amount expended by the city of Savannah for dredging, 1865 to 1872	157,000

The War Department has had nothing to do with any of these expenditures except the $150,000 first named.

The work executed up to the present time would necessarily and obviously be comprised in any judicious project for adapting the stream to the increasing demands of trade, with the exception, perhaps, of the dredging done by the city of Savannah north of the oyster-bed beacon, abreast of Fort Pulaski, which was discontinued when the United States engineer in charge commenced work in 1872. This work has consisted exclusively in removing wrecks, cribs, piles, and other obstructions placed in the channel during the civil war, and in dredging out channels over sundry shoals and bars between the city of Savannah and Tybee Roads.

The progress accomplished may be briefly summarized as follows:

The shoal northeast of Fort Pulaski.—To the northward of Cockspur Island, and separated from it by a water-way nearly half a mile in width, there is a small island known as the "Oyster Bed," with a channel on either side. In the natural condition of the stream, the north channel carried about 9 feet, and the south channel 10 feet, at mean low-water. These channels, uniting immediately below the Oyster Bed, formed the main ship-channel between that point and Tybee Roads, which passed to the northward of the Tybee Knoll light-ship. In entering the river, therefore, the light-ship was always left on the port hand, and then the Oyster Bed could be passed by taking either the north or the south channel. The authorities of Savannah City had dredged the north channel to a low-water depth of 12½ or 13 feet, but the work here was not continued by the United States engineer in charge when the first appropriation for resuming operations in 1872 became available, preference being given to the south channel, which has been opened in a straight line from the 19-foot channel, passing between Cockspur Island and the Oyster Bed to the main ship-channel below the light-ship. The new channel passes to the southward of the light-ship, where the low-water depth was only 9 feet. It is now 14½ feet deep for a width of about 160 feet, while the width between the 13-foot curves is fully 200 feet. The direction of the current is paralled to the axis of the new cut, for both ebb and flood, and there appears to be no tendency to fill up by the deposit of silt; but as the operation of widening the channel is now in progress, no positive opinion with regard to its permanency can now be expressed.

Elba Island Shoals.—Dredging has also been carried on at intervals since the autumn of 1872 upon the Elba Island Shoals, at points respectively opposite the lower end, opposite the middle, and opposite the upper end of that island. At the two points first named the work has been restricted to deepening and widening the existing channel, without any attempt to change its location to any considerable extent, and only where the direction of the ebb-current made a considerable angle with the axis of the channel. When the operations were begun the greatest draught that could be carried over these shoals at low-water was about 10 feet. The present depth is 13¼ feet opposite the lower end and 13½ feet opposite the middle of the island, with a width of

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about 120 feet at each point. There are no indications of shoaling by a deposit of silt.

The shoal opposite the upper end of Elba Island is at the point occupied by the double line of crib obstructions placed in the north or main channel during the civil war. The Coast Survey chart of 1855 shows that only 9 feet could be carried over this space at this time at mean low-tide, the best water being on the Elba Island side. After the removal of the obstructions, a channel was cut close to the north shore of Elba Island, to a depth of 13¼ feet and a width of over 100 feet. Subsequent soundings, taken by the Coast Survey in 1874, show a channel about 150 feet wide between the 12-foot curves, with a depth in the middle of 14 feet, except at the lower end, where only 13 feet is given. This would indicate a shoaling of 3 inches at one point, provided the required depth of 13¼ feet was actually established, were it not for the central depth of 14 feet throughout the other portion of the cut. It may be said in this connection that the volume of water passing through this north or main channel at the present time is somewhat larger than the normal flow previous to the civil war, for the reason that the line of crib obstructions placed in the channel south of Elba Island has been only partially removed, to accommodate the commerce of the inside passage by way of Saint Augustine Creek.

The Wrecks.—The next shoal encountered in ascending the river is opposite the lower end of Fig Island, at a point known as "The Wrecks," where it has been necessary to dredge from time to time within the last 30 years to maintain a practicable channel. This shoal owes its existence to the effects produced by the confluence of Back and Front rivers at this point, modified in all probability, with respect to its extent, position, and configuration, by wrecks sunk there during the revolutionary war. Notwithstanding the repeated attempts to establish a channel here by dredging, no permanent results have been achieved. During the latter half of the flood and the first half of the ebb the currents cross the line of the channel at an angle of 25 to 30 degrees. The consequence is that a deposit of silt takes place in the deepest water, especially on the ebb-current, which the scouring force of the inward and outward currents below half tide, although their direction is more nearly coincident with the axis of the channel-way, is unable to remove. "The Wrecks" channel was deepened at the expense of the city of Savannah after the close of the civil war. The United States continued the same policy as an imperative necessity upon the resumption of operations in 1872, for the reason that in no other way could the passage of vessels to and from the city of Savannah be provided for with the funds available for that object. The United States engineer in charge now recommends that a new channel, to be located near the south bank of the river, be cut through this shoal, and that "The Wrecks" channel be abandoned. (See project of May 13, 1875, given below.)

Garden Bank.—The extensive shoal known as Garden Bank reaches from the upper end of the bulk-head closing the old Fig Island Channel down to "The Wrecks," a distance of 2,400 yards. It is not continuous, but consists of 2 shoals, 1 above and 1 below the narrow point in the stream at Fig Island.

It has been necessary to dredge repeatedly along the south edge of the upper portion of this shoal in order to give a channel of sufficient width for vessels to lie two abreast at the wharves and give a passage-way alongside for ingress and egress. It may be necessary ultimately to remove by dredging all that portion of Garden Bank lying in front

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of the city within a width of 575 feet, but it is not expected that the improvement will be permanent, unless the water-way be suitably amended, and the flow in Front River very considerably augmented in volume.

The dredging upon Garden Bank has generally been restricted to shoal points projecting out into the channel and obstructing the approach to the wharves.

Obstructions removed.—The obstructions that have been removed from the channel between Fig Island and Fort Pulaski, since the year 1865, comprise 60 heavy timber cribs filled with brick or stone, 26 wrecks of vessels of various sizes, nearly 200 piles, and a large number of iron-shod snags, torpedoes, logs, &c. More than half of these obstructions were taken out by Mr. Henry S. Welles, under his contract with the Secretary of the Treasury.

Above the city of Savannah no work has been undertaken beyond making a thorough survey of Cross-Tides and gauging the streams in that locality.

From the results thus obtained, the United States engineer in charge made the following deductions in his general project of August 28, 1873, viz:

1. That the area of the Cross-Tides water-way is only about two-thirds that of the Savannah River water-way above Cross-Tides.
2. That the area of Front River water-way just below Cross-Tides is less than one-half that of the Savannah River water-way above Cross-Tides.
3. That the velocity of the ebb-current in Front River below Cross-Tides is only 0.64 of that in Savannah River above Cross-Tides, and 0.69 of the velocity in Cross-Tides.
4. That the Cross-Tides water-way is larger by one-third, and the ebb-current in it more rapid by one-half, than in Front River below Cross-Tides.
5. That nearly two-thirds of the water coming down the Savannah River flows through the Cross-Tides into Back River, while only one-third of it passes down Front River past the city-wharves.

Back River, therefore, is a stream of about double the capacity of Front River, a fact which suggests, as a probable remedy for those evils directly due to the comparatively small volume of water voided by the latter, the construction of works for diverting along the city-front a portion of the water which now flows through Back River.

The project of the United States engineer in charge for expending the existing appropriation, submitted to the consideration of the Board, is as follows:

UNITED STATES ENGINEER OFFICE,
New York, May 13, 1875.

GENERAL: The act of Congress approved March 3, 1875, appropriates for the improvement of the harbor at Savannah, Georgia, the sum of $70,000.

I propose to expend this sum during the next fiscal year substantially as set forth below:

First. In constructing a temporary deflecting-jetty of piles, sheet-piles, and string-pieces, about 450 yards in length, extending down stream from the lower end of Argyle Island, at the Cross-Tides, with the object of deflecting into Front River, along the city-wharves, a portion of the water which now flows through Cross-Tides into Back River.

A temporary jetty is recommended, for the reason that there is not money enough available for this improvement to construct a permanent work at Cross-Tides, and, in addition thereto, pay for the amount of dredging deemed necessary during the coming fiscal year. A temporary work will last several years, and will, it is thought, settle the question whether a dam across the Cross-Tides is really necessary. There are reasons why a dam should not be adopted, if a jetty can be made to answer the same purpose.

Even were there funds enough to cover the cost of a permanent work at Cross-Tides, it would be well, in my judgment, to try a temporary jetty first, as a precaution against the improper location of a permanent one, should the result indicate that a jetty will accomplish the end in view in a satisfactory manner.

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Estimated cost of temporary jetty	$6,500
Second. In deepening the channel between King's and Hutchinson's Islands to aid the flow into Front River, quantity of material to be removed, 8,000 cubic yards, at 27 cents per yard	2,160
Third. In dredging along the city-front to a depth of 14½ feet mean low-water.	9,700
Fourth. In opening a new channel near the south bank of the river, below the city and below Fig Island, with a view to abandoning the present circuitous channel at the lower end of Fig Island, known as "The Wrecks," the new channel to be opened during the coming fiscal year to a low-water depth of 14½ feet and a width of about 95 feet. Estimated quantity of material to be removed, 132,000 cubic yards, at 27 cents per yard	35,640

As this last-named item contemplates a departure to some extent from the project heretore submitted for the improvement of Savannah River, it is deemed proper to state that the dredging that has been expended from time to time in keeping the present Fig Island Channel open could not have been omitted in any degree without serious injury to the shipping interests. It was the channel kept open by more or less frequent dredging before the civil war began, and upon which the city of Savannah expended money quite liberally after the close of the war; but it is badly located, and is constantly filling up. It was thought that by changing its direction somewhat, so as to make it more nearly parallel to the direction of the current, it might be preserved. I do not believe it can be kept open without frequent dredging. (A chart showing the proposed channel is inclosed.) Until the pesent time it has never been possible, for want of funds, to establish the new channel.

Fifth. In increasing the depth of the present channel over the shoal abreast of Elba Island to 14½ or 15 feet at mean low-water for a portion of the present width of 125 feet	8,000
Sixth. In increasing to 14½ feet mean low-water the depth of the present new channel northeast of Fort Pulaski with the dredging-steamer Henry Burden, working 5 months, at $1,600 per month	8,000
Total	70,000

With the exception of providing employment for the "Henry Burden," the appropriation will be expended under the contract system.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Col. of Engineers, Bvt. Major-Gen. U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

The Board coincides with the views expressed in the annual report of the engineer in charge, submitted August 28, 1873, and approves of the general project for the improvement of Savannah River and harbor therein recommended to the Chief of Engineers.

With regard to the improvements and progress already made below "The Wrecks," the depths gained by dredging have, to the present time, been retained, and, at certain points, even have been increased by the currents.

These facts indicate that the localities were judiciously chosen; but further observation and experience of results would seem to the Board to be necessary to guide in the solution of the complicated problem presented in this lower section of the river.

The annual project submitted May 13, 1875, for carrying forward the work during the next fiscal year, also meets the approval of the Board, for the reasons stated below.

The characteristic features of this annual project, and the only ones demanding special mention, are—

1. A temporary deflecting-jetty at Cross Tides, projecting down stream from the lower end of Argyle Island.

2. A new channel to replace the existing one at "The Wrecks."

As a bare question of engineering, a crib-dam at Cross-Tides is preferred by the Board to a deflecting-jetty; either temporary or permanent,

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but inasmuch as the cost of a permanent dam cannot be defrayed from the existing appropriation without diminishing the amount of dredging that seems necessary at points below the city, and inasmuch as it appears to be very desirable that the volume of flow in Front River should be increased as soon as practicable, in order that work at points lower down may be conducted with reference to the new physical conditions thus imposed upon the stream, the jetty is recommended as a temporary device for increasing the volume of ebb-flow along the city front, and the scouring force upon Garden Bank, and upon the shoal at "The Wrecks."

The old jetty projecting from the upper end of King's Island should be removed in whole or in greatet part, if the amount of the appropriation will admit of it.

As auxiliary to the jetty the shallow water-way between King's and Hutchinson's Islands might advantageously be deepened to some extent by dredging, in order to increase the flow of both the ebb and the flood currents in Front River, and prevent the former from backing up in front of the jetty, and ultimately scouring a deep channel around its outer extremity into the Cross-Tides for want of adequate avenues of escape in the desired direction.

At "The Wrecks" the existing channel could doubtless be greatly improved by a deflecting jetty projected down stream from the south shore in a direction nearly parallel with the opposite shore of Fig Island. Such a jetty might indeed be sufficient, after the completion of the contemplated permanent work at Cross-Tides to keep "The Wrecks" channel open to the required depth.

It would, however, in the opinion of this Board, be an impediment to the flow of the flood-current into Front River, diminishing even the present volume of that flow, and would therefore impair to some extent the efficacy of the projected improvements, one of the leading features of which is to make Front River a flood-tide stream in an increased degree. The chart of 1874 shows broad and deep water along the south shore of the river for a length of nearly 2 miles below the shoal at "The Wrecks," extending for some distance up into the lower slope of the latter, in the form of a flood-tide pocket. A similar pocket exists in the upper slope of the shoal caused mainly by the ebb-current.

It is submitted that a channel connecting these two pockets, if judiciously located, will receive and discharge both the ebb and flood current in the direction of its axis. It will in addition thereto augment the volume of the flood entering Front River, for the reason that it is shorter by 300 feet, and more direct than the present channel.

It is not impossible that a deflecting jetty extending from Fig Island in a direction nearly due east, with its outer extremity resting near the head of the present narrow channel in about 12 feet water, will be required to keep this new channel open, but such a work is not recommended until the necessity for it shall have been demonstrated after the completion of the Cross-Tides improvement.

The water-way between the lower end of Fig Island and the upper limits of Savannah City should be amended, and its marginal limits defined and maintained under the exclusive authority of the United States.

The Board agrees with the engineer in charge in the opinion that the modification of the existing water-way along the city front should be made the subject of special study hereafter, when the effects of the contemplated improvements at Cross-Tides and at "The Wrecks" shall have become known.

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A chart of the Cross-Tides showing proposed location of the temporary jetty is submitted herewith.

Very respectfully, your obedient servants,

Z. B. TOWER,
Colonel of Engineers, Brevet Major-General.
H. G. WRIGHT,
Lieut. Col. of Engineers, Brevet Major-General.
JOHN NEWTON,
Lieut. Col. of Engineers, Brevet Major-General.
Q. A. GILLMORE,
Lieut. Col. of Engineers, Brevet Major-General, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., June 23, 1875.

SIR: The project submitted in your communication of the 13th May last, for the expenditure of the appropriation of $70,000 for the "improvement of the harbor of Savannah, Ga.," made by the act of March 3, 1875, having, after due consideration, been submitted to a Board of engineer officers for examination, and by it approved, it is also approved by this office.

You will please proceed accordingly in carrying on this work of improvement during the next fiscal year.

By command of Brigadier-General Humphreys.

Very respectfully, your obedient servant,

GEORGE H. ELLIOT,
Major of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers.

H 4.

UNITED STATES DREDGING-STEAMER HENRY BURDEN.

A full description of this vessel and its machinery and appliances for dredging was submitted with my last annual report, and published in the report of the Chief of Engineers, 1875, Part 2, Appendix U 3.

During a portion of the past fiscal year the steamer has been employed in dredging at different points in the Savannah River, and for a short time in the Beach Channel in Charleston Harbor. My reports on those improvements show the quantities of material removed in each locality. The working of the dredging apparatus continues to be entirely satisfactory, although, owing to the presence of contractors' equipments in the channels dredged, the accidental breaking of the rudder and main shaft of the steamer, and the delay and expense incident to their repair, the quantity of material removed was somewhat less than last year, and the average cost of removal per yard a trifle higher, as shown by the following table:

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	1874–'75.	1875–'76.
Least cost during any one day, per cubic yard	$0 06⅝	$0 06⅝
Least cost during any one week, per cubic yard	09	09⅛
Least cost during any one month, per cubic yard	10⅛	12½
Average cost for the year, per cubic yard	19⅛	21 1/16

These figures cover all expenses for superintendence, wages, and subsistence of crew, fuel, supplies, all repairs necessary to keep vessel and machinery in good order and prevent deterioration, and for the renewal of worn-out portions of pumping apparatus.

H 5.

INSIDE PASSAGE BETWEEN THE SAINT JOHN'S RIVER AND FERNANDINA, FLORIDA.

No operations were carried on during the past fiscal year at the mouth of the Saint John's River.

The act of Congress approved June 23, 1874, appropriated $10,000 "for continuing the improvement at the mouth of the Saint John's River, Florida, or may be used for dredging out the inside passage between Saint John's River and Nassau Inlet." The same act provided for a survey of the inside passage between Fernandina and Saint John's River, of which the inside passage above mentioned, between the same river and Nassau Inlet, forms a part.

With the approval of the Chief of Engineers, the work of dredging was postponed to await the completion of the survey and the preparation of a project and estimate for this improvement. This was completed and a report made, embodying suggested methods of improvement for the inside passage, accompanied by charts and estimates of cost, June 14, 1875.

After deducting the cost of the survey from the money appropriated by the above-mentioned act, the balance of the appropriation has been expended in dredging the inside passage.

The balance, $7,372.40, being too small to commence the general plan given in my report of the survey of this passage, it was determined to apply it to dredging at such points as would give the greatest depth and width over all the shoals in this channel, as shown on the maps accompanying that report.

Under authority granted in the letter of the Chief of Engineers, dated November 23, 1875, an agreement was made with the American Dredging Company to remove this material for 24 cents per cubic yard, the same as the contract-price of removing the material from the Savannah River. The greatest depth and width that it was found practicable to make over these shoals was 4 feet deep at mean low-water, and 40 feet wide, and the dredging was confined to those places where the channel was not of those dimensions.

The following are the places at which dredging was done:

In the Sister's Creek, that portion of the channel between Saint John's River and Fort George Inlet, the only place dredged was through the Oyster Shoal, between the Sister's Island, where the channel was entirely obstructed for a distance of 500 feet. Here a channel of the above dimensions was made, and 2,816 cubic yards were removed.

The other shoals dredged were in what is termed Sawpit Creek, or that portion of the channel between Fort George Inlet and Nassau In-

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let. The principal one is called Gunnison's Cut, and the others were the tailing shoals and middle ground immediately south of it. Through these latter, which in the improvement it was intended to avoid by making cut No. 2, (see report of survey,) a channel was made of the required dimensions by removing 400 cubic yards. At Gunnison's Cut, where the channel was completely closed for a distance of half a mile, the material to be dredged being very soft, it was found necessary to remove 25,757 cubic yards before a channel could be obtained of the dimensions determined upon.

The total number of cubic yards removed is 28,973, and there is now a channel not less than 40 feet wide and 4 feet deep, mean low-water, through the entire inside passage.

The same causes that formed these shoals will in all probability form them again, and the effect of the present improvement will be lost unless another appropriation is made for commencing the improvement recommended in my report of the survey. In this report an appropriation of $50,000 was recommended for the fiscal year ending June 30, 1877, and an additional appropriation of $50,000 is asked for the fiscal year ending June 30, 1878.

Money statement.

Amount available July 1, 1875	$7,372 40
Amount expended during fiscal year ending June 30, 1876	7,372 40
Amount (estimated) required for completion of existing project, $160,000 to.	370,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

H 6.

CHANNEL OF THE ENTRANCE TO CUMBERLAND SOUND.

UNITED STATES ENGINEER OFFICE,
New York, April 15, 1876.

GENERAL: I have the honor to acknowledge the receipt of a communication from the Office of the Chief of Engineers, dated December 15, 1875, transmitting to me, for report thereon, the following resolution adopted by the United States Senate December 13, 1875, viz:

Resolved, That the Secretary of War be requested to communicate to the Senate his views as to the importance and practicability of improving the channel of the entrance to Cumberland Sound, with estimates of the probable cost of the construction.

I also received, at the same time, for my information, a letter addressed to the Chief of Engineers on the 2d of November, 1875, by the Hon. D. L. Yulee, of Florida, accompanied by sundry documents and maps, all having reference to the subject embraced by the resolution of the Senate.

The bar which obstructs the entrance from the ocean to Cumberland Sound is commonly known as Fernandina Bar, and the anchorage inside as Fernandina Harbor. The northerly portion of this harbor, lying between the main-land and the south end of Cumberland Island, is called Cumberland Sound. The southerly portion borders on the north end of Amelia Island.

In 1843 that portion of the anchorage directly north of and adjacent to Amelia Island, starting from a point due north of Fort Clinch wharf, ran in an irregular curved line about due east, to the northward of the present main inner channel, and at distances from it varying from 70 to 250 yards. At a point about 2,300 yards east from this assumed starting-

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point; it crossed the present line of channel, running in a southeasterly direction, about parallel to the present western branch of the bar-channel, and 130 yards, more or less, to the southwest of it.

At a point a little over eight-tenths of a mile due east from the present east beacon on Amelia Island, it divided and crossed the bar in two branches, called the Eastern Channel and the Southern Channel, with a total divergence, at the 3-fathom curve outside the bar, of $3\frac{1}{2}$ miles.

The present main channel over the bar corresponds to this former Eastern Channel, although located over $\frac{3}{4}$ of a mile farther south.

The depths of the old inner channel, from the starting-point to the fork, varied from 27 to 68 feet. Over the same course the present depths vary from $19\frac{1}{2}$ to $46\frac{1}{2}$ feet; the greatest depths, then as now, being found north of Amelia Island, in what we shall term the Amelia Basin. The deepest water of the channel of 1875, corresponding to that portion of the main channel of 1843 inside the fork, shows on the map depths varying from $19\frac{1}{2}$ to $55\frac{1}{2}$ feet.

Going out from the fork above mentioned, the Southern Channel ran for half a mile in the same southeasterly direction as the main channel deviations in a southeasterly direction, until it crossed the outer 18-foot above the fork, when it swept around more to the south, with occasional curve after a course of 3 miles from the fork, and at a point east 12° south from Amelia Island light-house, and $2\frac{1}{4}$ miles from it. The depths in the Southern Channel ranged from 14 to 25 feet.

This course has shoaled to such a degree that it has ceased to be used by any class of vessels. Indeed, no channel over the bar has existed in that vicinity for the last twenty years or more.

The Eastern Channel of 1843, beginning at the fork, ran out in a somewhat crooked line, but its general direction was north 55° east, or about parallel to its course in later years down to the present time. Its minimum low-water depth in 1843 was 13 feet. The point where it debouched into deep water was about $1\frac{6}{10}$ miles distant from the fork. This eastern branch of the bar-channel exhibits an evident tendency to shift to the southward and eastward, while it remains parallel, or nearly so, to its direction in 1843. In 1856 its axis was about 900 yards southeast from its position in 1843, having traveled at the rate of about 70 yards per annum; in 1869 about 340 yards southeast from that in 1856, or 26 yards per annum; in 1874 about 320 yards southeast from that in 1869, and from the survey of December, 1875, and January, 1876, it appears that it has moved about 120 yards from its position in 1874.

In 1843 the length of the Eastern Channel between the inner and outer 18-foot curves was $1\frac{7}{10}$ miles, the least depth being 13 feet. In 1856 the whole length was about $1\frac{1}{2}$ miles, and the minimum depth 13 to 14 feet. In 1869 the whole length was $1\frac{7}{8}$ miles, with a minimum depth of 13 feet, while at the present time, although the average low-water depth is 14 feet, the least depth for a short distance is only $11\frac{1}{2}$ feet.

The 18-foot curves on the north and south sides of Amelia Basin have remained about stationary since the survey of 1843.

The north side of this basin is formed by shoals, some of them, like the Pelican Shoal, bare at low-water, extending a length of about 3 miles from the south point of Cumberland Island, in an easterly direction. A current observation made in the basin north of the location of the old wharf at Fort Clinch shows the direction of the ebb-tide to be about N. 68° E., being directed upon and apparently striking the south slope of the shoals at an oblique angle. The observation being stated to have been taken at a time when the influence of wind was small, this direction is to be considered as the natural outflow of ebb-tide at that

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point, being the resultant at the precise point of observation, though perhaps not the ultimate and final resultant of the outflows from Amelia River and Cumberland Sound. It seems more probable that the axis of Amelia Basin, which lies nearly east and west, gives the true mean direction of the combined ebb-currents from tho sources named.

Under this supposition it is not necessary to assume that the material composing the north shoal is of sufficient firmness to have resisted for a series of years the eroding action of these combined ebb-currents striking against it obliquely, but the inference is admissible that the permanent character of Amelia Basin is due to an equilibrium of hydraulic agencies rather than to any powers of resisting wear possessed by the sides of the channel on either side. Additional observations of the currents, and of the character of the bottom, are required in order to determine this point beyond doubt.

The eastern end of this basin has been steadily extending itself seaward, in a direction about north 68° east, forming at the present time a deep pocket reaching into the inner or western slope of the bar about three-quarters of a mile farther than it did in 1843, and correspondingly narrowing the bar at that point. According to the survey of the bar in January, 1876, this eastern end has, since 1874, advanced about 200 yards toward the sea.

The evident tendency is to cut through and form a new channel nearly parallel to the eastern channel of 1843, and about 450 yards to the northward of it, to take the place of that channel, in fact, while the latter, which has already moved south nearly 1,400 yards from its position in 1843, will, in time, under a continuance of the agencies that have been at work, replace the Southern Channel of 1843, which became extinct at least twenty years ago.

In 1843 the eastern end of this deep-water basin had also a southeastern deep-water pocket, directed toward and having a channel outlet to the ocean through the old Southern Channel. Since the closing of that channel this southeastern pocket has been greatly shortened by filling in, and at the present time does not extend as far south, by three-eighths of a mile, as the most southerly bend of the existing bar-channel.

The trend of the coast, from Saint Augustine, Fla., to Saint Andrew's Sound, Ga., a length of 80 miles, is nearly due north and south. It is fully exposed, therefore, to northeast, east, and southeast storms. There is no evidence of a prevailing littoral current, although the Coast Survey chart shows that the flood produces a northern and the ebb tide a southern current along the coast. The shifting character of the bar is due to the combined and ever-varying action of winds, waves, and tidal and storm currents. There are no tables of records, so far as I know, showing the duration and intensity of any of these agencies; and their relative influence, therefore, can only be inferred from the observed magnitude of the results produced, and these point to the superior aggregate force of northeast winds, and the waves and currents produced by them.

Supposing a channel to exist, forming an eastern outlet of the Amelia Basin in about a straight line with an assumed longitudinal axis of the basin, but unprotected by artificial works, the waves of translation, driven on by a northeast gale, having previously obtained great power and volume by rolling over an unlimited sea, will sweep along soft sand and broken shells and fill in the channel. The pent-up water of the flood-tides in Cumberland Sound and Fernandina Harbor will, under the influence of north and northeast winds, form an outlet in a more southerly direction. This motion of the channel will, of course, be retarded and complicated by the effects of southeasterly winds. In the

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course of years the channel will have been forced so far south, slewing around so much in a southerly direction, that its track across the bar will be greatly lengthened by its obliquity; the edges of its banks will more readily and frequently be broken down by waves. The liability to shoal, and the constantly-increasing obstructions, will so impede the outflow that a moment will arrive when, aided by favorable circumstances, such as spring-tides of uncommon height, in connection, perhaps, with freshets and strong westerly winds, the ebb-tide will break through the bar at some place more nearly in elongation of the deep-water axis of Amelia Basin, when, as in 1843, there will be two entrance-channels.

It would seem to be evident that with the facilities now afforded to the water to make its débouch through a shorter and more conveniently-located channel, the Southern Channel will pass a steadily diminishing volume of water, the deterioration of its banks will augment in a rapidly increasing ratio, and it will eventually fill up to a level with the surrounding bar and cease to be a ship-channel. This is the condition of things at the present time, and has been so for the last twenty years or more.

As to the outer 18-foot curve bordering on the ocean, it has, in the vicinity of the eastern end or mouth of the main channel, remained about stationary since 1869; but about 1¼ miles north, it has progressed seaward about one-fourth of a mile. As compared with the chart of 1856, however, the chart of 1875 shows that in the vicinity of the mouth of the main channel the deep water has gained since 1856, forcing back the outer 18-foot curve about one-fourth of a mile.

The whole length of the Fernandina bar, measured along its crest, is 7 miles, and the distance in a straight line between the two points where the ends join the shore is over 4 miles. Its southern portion, constituting fully three-fifths of its entire length, lies to the seaward of the general line of the coast, the most salient point on the outer 18-foot curve being 1¾ miles to the eastward of a straight line drawn tangent to the shore above and below the harbor. Its formation, maintenance, and changeable character are due to the combined action of the waves and tides, and not to the subsidence of sediment brought down by the streams (Amelia and Saint Mary's Rivers) which discharge their waters into Cumberland Sound.

FORMATION AND GROWTH OF BARS.

Delta bars are formed at the mouths of delta streams by material carried down by the stream and deposited at its mouth.

Drift-bars—so designated by General Humphreys—are formed by sand carried or drifted along the shore, and dropped in the mouths of streams, at times when the prevailing winds cause the waves to wash the shores obliquely, thus producing surf-currents along the shore, sometimes in one direction and sometimes in another, according to the direction of the obliquity.

Wave-bars are produced by the upheaving action of the waves, when they approach the shore and are converted by breaking into waves of translation. The bar is the result of their effort to maintain an unbroken beach across the mouth of the stream. The mouth of a river may be entirely closed by a single storm. Such was practically the case several years ago at the mouth of Black River, Ohio, after the east pier, first constructed, had disappeared. There was ordinarily 12 feet of water on the bar at its mouth, while inside 16 to 18 feet could be carried for a distance of 4 miles.

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There are few bars which owe their existence to any one of the foregoing causes, to the entire exclusion of the others. When the harbor or river empties into a tidal sea, the results are greatly modified, and in some cases largely controlled by the tide-currents.

The bar at the mouth of a delta stream, although it may be, and usually is, composed largely of the sediment furnished by the stream, is yet in the general case made up in part of drift material brought in by the surf on either side, and in part of material cast up by the waves.

If the stream is non-sedimentary and supplies no appreciable portion of the bar, the latter may be due almost exclusively either to the drift or to the action of the waves, modified in tidal waters by the ebb and flow of the tidal currents.

A drift-and-wave bar can, in most cases of streams which carry down a large rain-fall, be converted temporarily into a drift-bar only by the construction of parallel piers or jetties reaching from the shore to or beyond the crest of the bar, and then deepening the water between the jetties by dredging in case the scouring does not effect it. If the depth attained be such that the waves do not break on the bar, and thus become waves of translation, they will throw up little, if any, sand. The channel in this case will not shoal up rapidly until the drift accumulates on the outer side of the windward pier to such extent that it begins to escape around the end. A deposit will then ensue in the channel between the pier-heads, and a drift-bar will be formed. As soon as the water becomes shallow enough to cause the waves to break in the channel, the shoaling will be hastened, and the bar will then become a drift-and-wave bar.

The existence of the Fernandina bar and the changes which it is constantly undergoing are due to the combined action of winds, waves, and tides. It is in no sense, nor to any extent, a delta-bar.

In considering the question of the probable effects of jetties on the improvement of Fernandina Harbor, it is necessary to form an estimate of the volume of water received by the tidal or storage basin at average flood-tide, and of the amount discharged at ebb-tide, which includes the supply of fresh water by the Saint Mary's and other streams. This estimate cannot be other than a rude approximation, since only a few surface-current observations are shown on the Coast Survey chart, and only a small part of the tidal basin is given by that chart on a sufficiently large scale to allow a computation to be made of its area. The following pages will show the results of the investigation in that direction:

1. Area of tidal reservoir.
2. Its cubic contents between mean high and low water.

An approximate estimate of the area covered by the flood-tide, west of Amelia Basin, gives the following results:

	Square feet.
Amelia River	47,780,000
Dividing Basin, S. Amelia River	13,500,000
Jackson Creek	4,140,000
Kingsley's Cut	2,196,000
Lanceford Creek	24,748,000
Bell River	62,251,800
Jolly River	23,828,000
Saint Mary's River	115,500,000
North River	6,900,000
Cumberland Sound	388,000,000
All other creeks and inlets, say 10 per cent	68,884,380
Total area	757,728,180

Or about 27 square miles.

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The mean rise and fall of tide at Fernandina is 5.9 feet; at Saint Mary's, 6.3 feet. If the general average of rise and fall for the whole area is taken at 6 feet, the volume of water flowing out between Cumberland and Amelia Islands in a period of 6 hours and 15 minutes, which is the average duration of ebb-tide, is equal to 4,546,369,080 cubic feet. This is the total volume of the tidal basin between the planes of high and low water, and does not include any water derived from land-drainage.

Three profiles, marked I, II, and III, were drawn and calculated. Their location is shown in Plates I and II, their cross-sections on Plate III. It will be seen that II and III have the form of curves, which results from their being located in their proper positions normally to the direction of the various current-threads. Profile I was assumed to be in a straight line about normal or perpendicular to the average direction of the tide-currents in that vicinity, (tide observation No. 2 on the chart of 1875.) Dividing the ebb-tide into four quarters, the areas of Profile I, passed through by the water at these several stages, average as follows:

PROFILE I.—EBB.

	Square feet.
During first quarter, beginning at high-water slack	158,465
During second quarter	149,580
During third quarter	140,795
During fourth quarter	132,113
Mean area	145,238

The aggregate time occupied in passing these several areas or sub-profiles is 6 hours 15 minutes, or 22,500 seconds. The volume discharged during that time, not including the land-drainage, is estimated at 4,546,369,080 cubic feet. As a merely *preliminary* test, we will assume that this volume passes out at a uniform rate, that is, with a steady average velocity, and through an unchanging mean cross-section. On this hypothesis we find the volume discharged per second to be 202,061 cubic feet. The area of cross-section being 145,238 square feet, the mean velocity in such an ideal case would be 1.391 feet per second, or 0.948 mile per hour. According to DuBuat, the corresponding surface-velocity should be in this case 1.185 mile. By referring to current observation No. 2, (chart of 1875,) in the vicinity of profile I, we find the surface-velocities, commencing with 0 at high-water slack, to be 1.7 nautical miles at the end of the first quarter, 2.1 nautical miles at the end of the second quarter, and 1.7 nautical miles at the end of the third quarter. The average surface-velocity is, consequently, 1.38 nautical miles = 1.58 statute miles, or 0.40 mile more than that above calculated. This shows at once that the current must be of unequal force, stronger in the deep portions and weaker over the shoals near the shores. This fact has been demonstrated by many experiments, and expressed in formulæ. It has, among other proofs of its existence, as a law, been corroborated in an interesting manner by the important observations of Mr. Révy, on the Parana, the Uruguay, and the La Plata estuaries, (J. J. Révy, London, 1874.) In these great water-courses—

The velocity of the river, at any given cross-section, proved to be directly proportional to the depth. Thus, if a shoal occurs in the middle of the channel, the velocity of the current over the shoal is less than that of the deeper water on either side; and this diminution of speed is proportionate to the loss of depth. So direct is this relation that a plan of the surface-velocities, if projected on the appropriate scale, coincides very closely with the section of the bottom of the river. (Hydraulics of Great Rivers, Edinburg Review, 1874.)

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The calculated mean velocity was found to be 1.391 feet per second the observed average surface-velocity at ebb-tide 1.58 statute miles per hour = 2.33 feet per second, corresponding to a general mean velocity of 1.86 feet per second. To this velocity corresponds a certain head, or what amounts to the same thing, a mean hydraulic slope. This hydraulic slope is considered to be the same for all the different portions of the profile now under consideration, but it will produce different velocities, the greatest (1.86 feet per second) in deep water, and less toward the shoals. Making use of the formula of Downing, which is at once simple and assumed to be rather satisfactory for large discharges of water, we find

$$V = 100 \times \sqrt{R \times S}$$

where V = mean velocity in feet per second,
R = hydraulic radius, *i. e.*, area of profile divided by wet perimeter,
S = mean hydraulic slope,

from which we derive

$$S = \frac{V^2}{10000 \times R}$$

The mean aggregate area of the profile is 145,238 square feet; the volume per second 202,061 cubic feet at ebb-tide. To the mean velocity of 1.86 feet in deep water, corresponds, according to the formula, a mean hydraulic slope S = .0000088. If we divide profile I into seven compartments, according to depths, we obtain the mean velocity V in any compartment of which the mean hydraulic depth is r by the equation

$$V = 100 \times \sqrt{r \times S}$$

wherein the value of S is substituted as derived from the known velocity and hydraulic depth of the deepest compartment. The results which furnish one of the factors of the middle column in the following table show the lessened velocities of flowing water in the shallow portion of a profile, as compared with the greater velocities in the deeper parts.

Knowing the area of each compartment and its corresponding mean velocity, the volumes are found as follows:

First compartment,	7,393 ×	.92 =	6,802 cubic feet.
Second compartment,	27,294 ×	1.24 =	36,324 cubic feet.
Third compartment,	11,669 ×	1.4 =	16,337 cubic feet.
Fourth compartment	83,047 ×	1.86 =	154,467 cubic feet.
Fifth compartment,	9,126 ×	1.4 =	13,324 cubic feet.
Sixth compartment,	2,043 ×	1.26 =	2,574 cubic feet.
Seventh compartment,	2,832 ×	.82 =	2,322 cubic feet.
			232,150 cubic feet.

This exceeds the original estimate (202,061 cubic feet) by about 15 per cent.; but, in the first place, it is clear that reducing the size of the compartments or panels by increasing their number will result in a more correct computation, coming closer to the approximate volume of 202,061 cubic feet; secondly, that the flow on the shoaler portions has been already interfered with by friction, when arriving at the shore-ends of the profile; and, third, that the calculated discharge of 232,150 cubic feet per second, being based upon the *observed* mean hydraulic radii, includes the land-drainage of the Saint Mary's River and tributaries, which was not taken into account in the first estimate of 202,061 cubic feet discharged per second.

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VOLUMES OF EBB AND FLOOD TIDES.

We shall now consider more in detail the flow of tides in Fernandina Harbor, beginning with the ebb-tide, and calculating its volumes of flow through Profiles I, II, and III, and Plates I, II, and III.

Ebb-tides.—We will commence with Profile I, located as already described. The ebb-tide is stated to last 6 hours 15 minutes. From a rather careful and detailed computation it is found that, beginning at high-water slack, the following volumes pass during the four quarters of the ebb-tide, the duration of each quarter being 1 hour 33 minutes 45 seconds, or 5,625 seconds. For each quarter the profile was divided into seven compartments, according to the most striking variations of depths, the area of each, and its own wetted perimeter ascertained, and its special mean velocity deduced by means of D'Aubuisson-Downing's formula:

PROFILE I.—EBB.

Volumes per second in cubic feet.

Number of quarter.	Total volume.	Between 18-foot curves.	Between 24-foot curves.
First	152,708	119,145, or 78 per cent. of whole.	98,517, or 64.5 per cent. of whole.
Second	323,062	256,466, or 80 per cent. of whole.	213,153, or 66 per cent. of whole.
Third	304,656	245,318, or 80 per cent. of whole.	205,074, or 67.3 per cent. of whole.
Fourth	126,589	104,003, or 82.2 per cent. of whole.	87,794, or 69.3 per cent. of whole.
Average	226,754	181,233, or 80 per cent. of whole.	151,117, or 66.6 per cent. of whole.

This table shows that by far the largest portion of the ebb takes the deep channel, and that as the tide continues the proportional amount flowing in the deep channel increases. We perceive also that during the first half ebb the discharge exceeds that of the second half. The aggregate discharge of one full ebb-tide will therefore be as follows:

PROFILE I.—EBB.

	Cubic feet.
Volume of first quarter	858,982,500
Volume of second quarter	1,817,223,750
Volume of third quarter	1,713,690,750
Volume of fourth quarter	712,063,375
Volume of one ebb-tide	5,101,960,375

This volume exceeds by about 12 per cent. the volume of 4,546,369,080 cubic feet, calculated from quite a different basis. That the outflow should exceed the amount of stored-up flood-water is clear enough; the quantity of excess will depend on the hydraulic state of the Saint Mary's River, and the other tributaries.

Profile II. This profile is located lower down the Amelia Basin, taken normally to the average direction of the currents of observation No. 5, (chart 1875.) It is a partial profile, touching shore only on its southern end where it crosses Kingsley's Bank. The other end terminates on the north shoal.

The observed surface-velocities of the ebb-tide, at the deep-water portions of this profile, are 1.9, 2.6, and 2 nautical miles per hour, at the end of the first, second, and third quarters, respectively. From these data we deduce the various velocities for the different depth-compartments of the profiles of the first, second, third, and fourth quarter ebb, and, having these, we obtain the volumes.

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PROFILE II.—EBB.

Volumes per second in cubic feet.

Number of quarter.	Total volume.	Between 18-foot curves.	Between 24-foot curves.
First	106,670	85,892, or 80.6 per cent. of whole..	75,110, or 70.5 per cent. of whole.
Second	234,401	194.110, or 82.8 per cent. of whole..	171,407, or 74.1 per cent of whole.
Third	223,388	191,381, or 85.6 per cent. of whole..	168,832, or 75.6 per cent. of whole.
Fourth	89,688	79,258, or 88.3 per cent. of whole..	70,140, or 78.2 per cent. of whole.
Average	163,536	137,662, or 84.2 per cent. of whole..	121,372, or 74.2 per cent. of whole.

Comparing this table with that of Profile I, it is found that 72 per cent. of the whole volume that passed Profile I flows through the partial Profile II, including Kingsley's Bank. Consequently, while the ebb-tide moves from Profile I to II, a distance of $1\frac{3}{4}$ miles measured along the deep-water channel, 28 *per cent. of the whole volume escapes in a northerly direction through Cumberland Channel and across Pelican and other shoals.* In both profiles the proportion of water taking the deep channel increases with each succeeding quarter—*i. e.*, as the tide lowers—a fact which is more strongly marked in Profile II than in Profile I, showing that the *resistance to sideway-spreading over the northern shoals augments as the height of the tide decreases.*

Profile III. This is also a partial profile, located on the western or inner slope of the bar, and crossing the present main channel. This profile necessarily presents a considerably curved line, on the principle that a profile should always, as nearly as possible, be normal to the direction of the currents. It is located so as to take in the two current observations, Nos. 8 and 10, (chart of 1875,) and to cross the eastern end of the eastern deep-water pocket of Amelia Basin. Of the observed velocities of Nos. 8 and 10, averages were taken and assumed to apply to that part of the profile situated about midway between the two points of observation; and on that basis the various velocities resulting for the different depth compartments of the profile were calculated by using Downing's formula.

The profile extends from Amelia Island across the existing ship-channel on the bar, and across the eastern end of the deep-water pocket, to the 6-foot curve of the north breakers.

PROFILE III.—EBB.

Volumes per second in cubic feet.

No. of quarter.	Total volume.	In main channel.	In deep-water pocket.
First	78,250	19,037, or 24.3 per cent. of whole	11,100, or 14 per cent. of whole.
Second	245,941	55,845, or 22.7 per cent. of whole	33,369, or 13.6 per cent. of whole.
Third	213,085	48.735, or 22.9 per cent. of whole	30,158, or 14.1 per cent. of whole.
Fourth	53,549	12.497, or 23 35 per cent. of whole	8,058, or 15 per cent. of whole.
Average	147,706	34.028, or 23 per cent. of whole	20,671, or 14 per cent. of whole.

By comparing the average discharge (147,706 cubic feet) of Profile III with the average discharge (163,536 cubic feet) of Profile II, a difference of 9.7 per cent. is found. This amount, which is equal to 7 per cent. of the total ebb-flow through Profile I, passes out over the shoals of the north breakers while the ebb-tide is moving from II to III. *From I to III, therefore, 35 per cent. of the whole discharge escapes across the north breakers, of which amount 28 per cent. passes between I and II and 7 per*

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cent. between II and III. By measuring the line from I to III along the shoals on the southern borders of the north breakers, we find that, for equal lengths, more water escapes, comparatively, between Cumberland Island and Pelican Shoal than farther out, as might have been expected from the greater depths of Cumberland Channel. If we take the whole length of shoal line from Cumberland Point to the north end of Profile III to be about 5,400 yards, as measured on the chart, then, between I and III, 1 per cent. of the total discharge escapes at every linear length of 154 yards. But by considering only the distance from I to III (3,875 yards) we find 1 per cent. flowing out in a northerly direction over every length of 138 yards, on an average, while from II to III, 1 per cent. flows out over every length of 218 yards. This seems to indicate the deflecting influence of the shoals of the north breakers during ebb-tide.

It is also seen, by inspecting the tables of Profiles I, II, and III, that, during the first half of the ebb, the discharge is always larger than during the second half, and that of the discharges during the four quarters, those of the second quarter are uniformly the largest. In Profile I the discharge of the first half of ebb is 5 per cent. larger than during the second half; in Profile II nearly 7 per cent., and in III 10 per cent.

FLOOD-TIDES.

The duration of the flood is stated to be 6 hours 9 minutes. Computations have been made of the volumes of water received during each of the four quarters of flood, of Profiles I, II, and III. The following are the results:

PROFILE I.—FLOOD.

Volumes per second in cubic feet.

No. of quarter.	Total volume.	Between 18-foot curves.	Between 24-foot curves.
First	67, 790	55,743, or 82.2 per cent. of whole	46,940, or 69.2 per cent. of whole.
Second	242, 742	195,422, or 80 5 per cent. of whole	163,418, or 67.3 per cent. of whole.
Third	340, 710	269,595, or 79.1 per cent. of whole	224,810, or 66 per cent. of whole.
Fourth	148, 687	115,190, or 77.5 per cent. of whole	95,925, or 64 5 per cent. of whole.
Average	199, 982	154,190, or 77.3 per cent. of whole	132,773, or 66.4 per cent. of whole.

It has been found that if the estimate of accumulated flood-water in the reservoir composing Cumberland Sound and the connecting creeks and estuaries be approximately correct, then there ought to be an outflow averaging 202,061 cubic feet per second discharged, for draining off the reservoir to low-water level, while the inflow should average 205,346 cubic feet per second, in view of the shorter duration of the flood-tide. The table above shows that 199,982 cubic feet per second are received on an average, a deficiency of from 2 to 3 per cent. This difference ought to represent the water supplied to the tidal reservoir by land-drainage, which it does with a close approximation to the calculated supply from that source. If the discrepancy were a large one, it might be accounted for in various ways. For instance, it is quite probable that after the real ebb-tide has already ceased, the river-water, which at low-water has its outflow least obstructed, still continues to run out on top of the salt water, apparently, though not in fact prolonging the ebb, while below it the sea-water already begins to flow inward, and thus in reality lengthening the apparent time of flood and shortening the apparent time of ebb.

As stated by Mr. D. Stevenson, it must be borne in mind "that the

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application of any known formula to the determination of the mean velocity and discharge of a river is shown by experimental inquiry to afford only a rough approximation, unless observations are made embracing the velocities at different parts of the cross-sections." In deep places these velocities should, if possible, be taken with the tachometer or stream-gauge, to determine the velocity as the stream or current passes the line of cross-sections. As to the under-currents, Mr. Stevenson says that caution must be observed, since the rules from which the mean velocities are deduced assume that they bear a constant ratio to the surface-velocities, which does not apply to many situations which are within the influence of the tide. In surveying the Dee at Aberdeen, Mr. Robert Stephenson found that, while there was an outward upper current of fresh water, there was an inward under-current of salt water. Another instance of such an under-current, though not occasioned by the presence of a river, was found to exist in a marked degree at the Cromarcy Firth, where Mr. Alan Stevenson found (in 1837) currents greatly exceeding the surface-velocity. It must be remembered that only a very few observed velocities are given on the chart, and that those used in the calculations are therefore only approximately correct, or, if entirely correct in some cases, are not known to be so.

In the absence of any positive proofs of the existence of a prolongation of the flood and of any increased under-currents not shown by the adopted formula, it is thought best to let the results shown in the table of floods in Profile I stand as they are, and consider that any modification that ought to apply to them would apply in equal proportion to the other profiles.

PROFILE II.—FLOOD.

Volumes per second in cubic feet.

No. of quarter.	Total volume.	Between 18-foot curves.	Between 24-foot curves.
First	49,178	43,450, or 83.3 per cent. of whole	38,890, or 79 per cent. of whole.
Second	161,509	137,980, or 85.4 per cent. of whole	121,450, or 75.2 per cent. of whole.
Third	196,463	163,163, or 83 per cent. of whole	143,122, or 72.8 per cent. of whole.
Fourth	87,238	70,460, or 80 8 per cent. of whole	61,614, or 70.6 per cent. of whole.
Average	123,572	101,450, or 82.1 per cent. of whole	91,233, or 73 8 per cent. of whole.

By comparing this table with that of Profile I, it is seen that 62 *per cent. of the whole volume passing Profile I at the flood* flows through Profile II, including Kingsley's Bank. *Consequently* 38 *per cent., or an average of* 75,992 *cubic feet per second, of the flood-tide enters between the Profiles I and II, in a southerly and southwesterly direction, through Cumberland Channel and across Pelican and other shoals.* It has also been shown that *over precisely the same route* 28 *per cent. of the ebb-tide, or an average of* 63,218 *cubic feet per second, escapes to the north,* which indicates that the volume of flood exceeds the volume of ebb passing over this northern portion of the main bar by about 12 per cent. The effect is to make the inner slope of this part of the bar very steep; the sand which is rolled along by the flood current on the bottom of the outer slope is first brought to rest in the deep water of the inner basin. The ensuing ebb-current, which receives its velocity and direction from the large volume of Cumberland Sound, sweeps the inner slope of the northern shoals longitudinally, and takes up this sand and carries it out by the Amelia Basin, depositing it upon the main bar. The channel next to Cumberland Island is therefore a flood-tide channel, like the Sullivan's Island or Beach Channel, in Charleston Harbor. They both possess in a marked degree the steep inner slope which invariably characterizes a channel maintained by the flood-tide, which, having

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once passed in, is so much diverted in its direction on the ebb by the axial line of the tidal basin that it cannot flow out in full volume through the same opening, but sweeps past its mouth in its passage to some more direct outlet.

In both profiles the proportion of water taking the deep-water channel decreases as the tides rises, showing that the guiding influence of the shoals is less felt as they grow more deeply immersed.

PROFILE III.—FLOOD.

Volumes per second in cubic feet.

Number of quarter.	Total volume.	In main channel.	In deep-water pocket.
First	54,150	15,092, or about 28 per cent.	12,704, or 23.4 per cent.
Second	145,629	38 852, or about 26.6 per cent.	33,714, or 23 per cent.
Third	157,159	40,488, or about 25.8 per cent.	35,770, or 22.8 per cent.
Fourth	65,147	17,607, or about 27 per cent	15,864, or 24 per cent.
Average	105,521	28,009, or about 26.5 per cent.	24,513, or 23.2 per cent.

Comparing Profile III with Profile I, it is found that only 52.7 *per cent of the total volume entering through Profile I passes through Profile III; therefore, 47.3 per cent. of it flows in across the shoals of the north breakers and Cumberland Channel.*

But we have already seen that 38 per cent. of the total flow passes in between Cumberland Island and Profile II, so that only 9.3 per cent. passes between Profile II and Profile III. By observing the length of this shoal it will be seen that less water passes in between Profiles II and III than over an equal length of shoal-line nearer to Cumberland Point, a result which agrees with the previous deduction, that Cumberland Channel is mainly due to the flood-current.

An attempt has been made to represent graphically, in Plate I, the distribution of the flood-tide, based on the calculated volumes of the different compartments or Profiles I, II, and III, as well as of two intermediate profiles not represented, and on the observed directions of flood-tide observations, Nos. 2, 5, 7, 8, and 10. The space between each two adjoining full lines represents a volume of 10,000 cubic feet per second of flood-tide water flowing toward Cumberland Sound.

Plate I shows the probable direction of the threads of currents of flood-tide, and the distribution of its average volume, or a mean of the volumes of inflow per second during the four quarters.

THE RAIN-FALL.

The Saint Mary's River and the other tributaries to Fernandina Harbor drain an area of about 1,700 square miles.

The average rain-fall in that locality is assumed to be 50 inches per annum, or .137 inch, = .0114 foot per day. Allowing $\frac{5}{10}$ for evaporation, soakage, and other losses, there remains .00557 foot daily. This amounts to a volume of 155,280 cubic feet per day for each square mile, which flows out in not quite two ebb-tides; equal to a discharge of about 6,050 cubic feet per second. Adding this quantity to 202,061 cubic feet, the estimated volume of stored-up flood-water between the levels of ordinary high and low water, we get an average of 208,111 cubic feet which should go out during each second of ebb-tide. The calculated amount of ebb was found to be 226,754 cubic feet per second; an excess of only a little over 9 per cent. But it can easily be shown that *this difference must be very variable*, and that the excess may be occasionally on the other side. Allowing 1 inch rain-fall in one day, (which is not excessive for a heavy rain-storm, even allowing for losses,) we obtain a discharge, by land-water alone, equal to 87,720 cubic feet

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per second, on the basis of an average length of flow in the river of 50 miles, (one hundred miles being the whole length of the river,) with a mean velocity of two miles per hour. This would entirely reverse the relation, giving for the actual outflow during ebb-tide a volume of 28 per cent. larger than the amount given in the table headed "Profile I, Ebb." It would show that, in order to obtain anything like a correct idea of the average volume passing out at ebb-tide, we should know, besides the soundings and the few ebb-current observations given on the Coast Survey chart, whether the river was at its average stage or was under the influence of freshets, or the reverse.

Indeed, we should have in our possession or within our reach some method of making a proper allowance for abnormal conditions of the stream due to variations in the amount of rain-fall. With such a vast addition of land-water after heavy rain-storms, the ebb-tide increases largely in volume and momentum, so that, with a concurrence of spring-tides, strong westerly winds, and heavy rain-falls, the eastern deep-water pockets would be pushed still further out into the inner slope of the bar, the bar-channel would be deepened by scouring, and the bar itself, at the débouchure of the principal channel, would be extended into the sea and assume a more salient curve. A similar effect on the bar-channel and on the bar itself in the vicinity of its outlet into deep water would be the result of confining the ordinary or average ebb-tide between guiding jetties that would not exclude the flood, so that on the ebb it would impinge upon the bar in a volume of diminished width and increased depth, and therefore with increased velocity; that is, the existing channel would be deepened and the existing bar be moved out seaward, by moving out the scene of conflict between the waves and tides, to which the bar owes not only its existence but its fluctuating and ever-changing character. If to this supposed condition of completed jetties we superadd the hypothesis of a prolonged season of quiet sea, with its twice daily ebb and flow entirely undisturbed by wave-producing winds, the bar would soon assume a condition of stability, with a permanent channel across it, exterior to the heads of the jetties, of a certain depth and width, corresponding to the distance between the heads of the jetties and their position with respect to the crest of the original bar. The practical dimensions which this exterior channel would assume—that is, its length, breadth, and least mid-channel depth—cannot be predicted with any close approximation to accuracy, even under the assumption that all winds and waves are for a time held in abeyance in its favor. The most that can be said is that under these impossible conditions a deep and stable channel would doubtless be secured, for the sufficient reason that the action of the principal natural agencies which prevent the maintenance of channels at the mouths of tidal harbors, and even destroy them when formed artificially, is supposed to be suspended, and in addition to this we, by artificial means, place the outflowing water under the most favorable conditions for scouring out a channel in a bar already existing. Indeed, were there no winds and waves, there would doubtless be a good bar-channel at Fernandina Harbor without resorting to jetties.

In dealing with the question as it exists, however, without excluding the effects of winds and waves, it presents itself under an entirely different aspect, and is full of perplexing difficulties, which elude not only the analogies of experience, but all the known methods of research by formulæ.

Mr. Thomas Stevenson says:

The preservation of the depth of harbors at a level *lower* than that of the original bottom involves both uncertainty and expense. Where the deposit is confined to the

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space between high and low water marks, the scouring by means of salt or fresh water is comparatively easy; but where it forms a bar outside of the entrance, the possibility of maintaining permanently a greater depth becomes very doubtful. The efficacy of the scour, so long as it is not impeded by enlargements of the channel may be kept up for a great distance, *but it soon comes to an end after it meets the sea.*

The only available force which can to any extent be brought under control to promote the object in view of deepening the bar-channel is the abrading or scouring power of the currents, and it is the excess of the scouring-power of the ebb over that of the flood currents which gives value to this agent.

This excess is due to two causes, viz:

1. To the rain-fall of the natural drainage-area of the tidal basin, which in the case of Fernandina Harbor is equivalent to 1,700 square miles.

2. To the volume of water carried in over the bar at or near the surface by waves of translation, which afterward forms a part of the general outflow. High jetties, or those which rise above the level of high-water, will cut off all supply from this source, except what little is carried in between them.

JETTIES.

1. Full-height jetties, extending across the bar.
2. Full-height jetties, reaching to the crest of the bar.
3. Stump-jetties, about one mile long each.
4. Full-length drowned jetties.
5. Full-length drowned north jetty and full-height south jetty.

1.—Full-height jetties extending across the bar.

As already stated, the effects that will be produced by jetties upon the entrance to a tidal harbor cannot be ascertained in advance of their construction by any known method with any close approximation to certainty. The formulæ given by the highest theoretical authorities in hydrodynamics, by Proy, D'Aubuisson, Eytelweir, Rankin, Weisbach, and others, concerning the discharge of water-courses, are based on observations of small channels of regular cross-section. An attempt to take account of the effects of irregularities in the cross-section on the volume and method of discharge leads to most complicated forms of equations, with no guarantee that the final result of the calculation can be relied on as approximately accurate. In the improvement of a harbor several elements have to be considered, which it would be simply impossible to express and incorporate in a comprehensive formula. Each harbor has to be studied for itself. From the observed phenomena peculiar to it, such as dominating winds; the direction and strength of ebb and flood littoral currents; the direction and action of the waves; the influence of fresh-water rivers, if such empty into the bay, at their various stages of level; the formation of the bar and the character of the materials composing it; the trend of the coast, &c., conclusions have to be drawn with regard to the position, direction, length, and distance apart of the jetties, which cannot be other than largely problematical.

"There are few maritime constructions," says M. Minard, in his work on harbor-constructions, "less susceptible of general rules and more dependent on local influences than jetties." He might have added that we are as yet unable to deal with these local influences with much confidence or satisfaction.

This being the first time that the entrance of Cumberland Sound has been made a subject of study with a view to its improvement by jetties, reliance must be had chiefly on the deductions that can be made from

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the observations of the distribution of the waters of ebb and flood tide through Amelia Basin and over the bar, and from the history of the bar and its ship-channel, as contained in the charts of surveys made since 1843. These charts and the changes which they record have already been briefly discussed.

If the jetties be supposed to be full-height, reaching from the shore on either side, their first effects will be the same in character, though not in degree, with respect to their practical value, whether their heads rest in shoal water on the crest of the bar or extend into greater depths beyond. In either case the width between the jetties may be so adjusted that the scour will produce a temporary channel as far out as the jetty-heads, and somewhat farther, of sufficient depth for all practical purposes.

Let us first suppose that the jetties reach across the bar, as shown by the lines A B J and C D M, Plate II. In Profile I, where the *whole amount* of ebb and flood passes, we find a total width of cross-section at mean low-water of 5,720 feet, with an average depth of 21.33 feet. This means, of course, that if the cross-section had a rectangular form it would measure 5,720 feet by 21.33 feet. The deep-water portion of this profile, between the 24 foot depths north and south, has a width of 2,100 feet, the depth ranging from 24 feet to 48 feet, corresponding to a mean low-water depth of 36 feet. We may conclude, then, that if the jetties have the same width of 5,720 feet between them, similar results will be obtained, provided the same volume of flood can be collected as now. If it were possible to drop the full-height jetties down in place, ready made, at high-water slack, of course the ebb-current would be compelled to pass out between the heads of jetties, and a violent scour would be produced. Indeed, we can imagine a bar composed of materials so soft and light that the scour of a single ebb-tide would produce a water-way through it of equivalent area to that of Profile I. Such would probably not be the result, however, in the case under consideration. The diminished discharge caused by the bar, contracted by the jetties to a length along its crest of only 5,720 feet, would prevent the lowering of the inner reservoir as rapidly as the tide fell on the outside. A banking up of water would therefore be the result between the jetties inside the bar, producing for a time a violent outgoing current and scour, which would continue with diminishing force during the period of slack-water, ebb, and longer. At a certain stage of the ensuing flood the water inside and outside would be brought to the same level, and all outflow would cease before the tidal basin had been lowered to low-water level. At a later period of the same flood there would be a banking up of water outside the jetties, and an inward scour would take place, and continue until the waters inside and outside again attained the same level. In this manner, by a succession of inward and outward scours, the existing bar between the jetties would be removed by the formation of a water-way through it of equivalent section to Profile I. A portion of the eroded material will pass inward, but a greater portion outward, because the volume of the ebb is greater than that of the flood by the amount of rain-fall and land-drainage received by the inner basin, and because the first scour was supposed to be outward and due to a full inner basin.

If, on the contrary, the full-height jetties be supposed to be suddenly set in place at the time of low-water slack, there would be a banking up of water outside on the ensuing flood, and the first scour would be inward. But the same result would doubtless be reached in about the same length of time as under the former supposition, and Profile I or its equivalent would be continued out to the heads of the jetties.

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Although in practice the jetties would, in their construction, rise gradually from their foundations, and increase gradually in length, the ultimate results brought about by their agency, when they shall cease to be the direct cause of further progressive changes, will be essentially the same as in either of the hypothetical cases just mentioned; that is, we shall have all the way from Profile I to near the heads of the jetties a water-way of about the same sectional area as that profile.

After this the tides will ebb and flow through the water-way between the jetties without causing any greater changes, probably, than have taken place during the thirty years in the channel between Cumberland and Amelia islands. But outside the jetties certain important changes will also be in operation. All the material eroded from the bar that cannot remain inside without contracting the inner water-way below the area of Profile I must finally pass out and come to rest in the deep water on the outer slope of the bar. The first result will therefore be a deeper channel of entrance.

The littoral ocean-current of flood-tide, running in a northerly direction, will form eddies in the exterior angle between each jetty and the shore to which it is attached. (Figure 1, Plate III.) Shoaling in these angles will therefore take place from this cause, but principally from drift-sand brought in by waves. Northeasterly and easterly storms will gradually fill in the angle north of the north jetty, and southeasterly storms that south of the south jetty. Eddying waters will also be caused in both of these angles by the southerly littoral current of ebb-tides. (Figure 2, Plate III.) The direction of this current is about southeast by south, and its action upon the water in the angle south of the south jetty will be to draw it out and lower its level, while the water issuing from between the jetties, being at once deflected in a southerly direction, will form eddies therein and cause shoaling by deposits. This action might be obviated, but without any modification of the final result, by locating the shore end of the Amelia Island jetty more to the southward, without changing its head; that is, by placing the dead-angle inside the jetty, as shown in Figure 2, Plate III. But whatever location might be given to the jetties, and whatever might be their length, the inevitable consequence would be that the exterior angles would fill in with sand, and the shore-lines would be extended seaward to points near their outer extremities, giving an increased width to both Amelia and Cumberland islands for considerable distances from the outlet, north and south. After this stage was reached, the drift produced by waves striking the shore obliquely, instead of accumulating in the angles already filled up outside the jetties, would be carried around their ends and dropped in the channel, to be subsequently moved out by the ebb-current from the harbor and deposited in the deeper waters beyond the present bar, at some point where the velocity of the outgoing currents would be so far diminished by dispersion and by resistance from the sea that it could not transport it farther. In this manner a new bar would be formed exterior to the present one. In other words, the present bar would be gradually extended into the ocean, and there seems no reason to doubt that the channel across it would be subjected to the same incessant changes in depth, location, and direction, from the action of winds, waves, and currents, that characterize the present bar-channel. It would appear, indeed, that by artificial works we have simply moved the natural mouth of Cumberland Sound from Profile I, between the two islands, out to the head of the jetties, and have, therefore, from necessity, established the requisite conditions for the creation of a new bar, which shall ultimately bear essentially the same relation to this artificial mouth that the present bar

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bears to the present mouth at Profile I. It is impossible to foretell the rate at which this prospective bar would form. It would be unsafe to reason from any analogous case, if such existed. We are, however, deprived of even this kind of data. I know of no attempt to improve by jetties the bar-entrance to any harbor at all resembling that of Fernandina in character, location, and kind and degree of exposure. If the bar was caused in large measure by a delta-stream like the Mississippi or the Rhone, and had, like them, been the object of numerous and careful observations, extending through many consecutive years, we would be able to form something like a rational opinion on this branch of the question. What we know is that the agencies which formed and maintain the present bar will possess as much power and will have as favorable a field for action after the construction of the jetties as before, and that their construction supplies all the requisite conditions for the creation and maintenance of a new bar, having its crest nearly, if not quite, as far beyond the heads of the jetties as the latter are beyond the natural mouth of Cumberland Sound, between the points of the islands. I say *nearly, if not quite, as far*, because it seems probable that the new bar would present such a salient curve to the action of the littoral ebb and flood currents of the ocean, and of waves striking it obliquely, that its outer slope would be eroded, and the materials carried above and below the outlet in a greater degree than the corresponding portion of the present bar is affected by the same causes.

2.—*Full-height jetties reaching to the crest of the bar.*

This question will be considered a little more in detail, on the assumption that the heads of the jetties are three-fourths of a mile apart and rest on the crest of the bar, as shown at A B and C D, Plate II. For purposes of discussion, it will be supposed that the jetties are suddenly placed in position at the slack-water of flood, and that the entire volume in the reservoir between high and low water levels passes out at the ensuing ebb-tide.

Profile IV, taken on the line B D—that is, between heads of jetties—contains 48,158 square feet at *low-water*, with an average low-water depth of 12.16 feet. Through this profile a volume must pass during the first quarter ebb equal to 152,708 cubic feet. At profile I this volume passes through a cross-section of 155,754 square feet, with a mean depth of 26.13 and an average velocity of .98 foot per second. From the detailed calculations the two following tables of comparison are made of Profiles I and IV, the latter being between the ends of the jetties.

TABLE A.—PROFILE I, EBB.

Number of quarter.	Mean area.	Hydrographic mean depth.	Mean velocity per second.	Mean volume per second.
	Square feet.	*Feet.*	*Feet.*	*Cubic feet.*
First	155,754	26.13	.98	152,708
Second	146,872	24.92	2.2	323,062
Third	138,228	23.77	2.2	304,656
Fourth	129,428	22.50	.98	126,589

Mean depth of whole profile at low-water = 21.33 feet.
Width of profile at low-water = 5,270 feet.
Mean depth at low-water, in deep portion of profile, *i. e.*, between 24′ lines, = 36 feet.
Width of deep portions between 24′ lines = 2,100 feet.
Proportion of general mean depth (21′.33) to mean depth in deep channel (36′) = 1 : 1.7.

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TABLE B.—PROFILE IV, EBB. (*See Plate III.*)

[It is assumed that the same volumes per second and per quarter pass this profile as at Profile I.]

Number of quarter.	Mean area.	Mean depth.	Mean velocity per second.	Mean volume per second.
	Square feet.	*Feet.*	*Feet.*	*Cubic feet.*
First	68,948	17.23	2.22	152,708
Second	63,008	15.75	5.13	323,062
Third	57,018	14.25	5.34	304,656
Fourth	51,128	12.78	2.48	126,589

Width of profile between jetties = 3,960.
Mean depth of profile = 12'.16 at low-water.

The mean velocities found in the Table B, reduced to bottom-depths in the usual way, will be: 1.67 feet, 3.85 feet, 4 feet, and 1.86 feet for the four quarters, respectively. According to Du Buat, a current-velocity close to the bed of $2\frac{1}{4}$ feet per second will move gravel 1 inch in diameter, while a velocity of $3\frac{1}{3}$ feet will move pebbles $1\frac{1}{2}$ inches in diameter. The bar being composed, as the Coast Survey chart informs us, of gravelly sand and broken shells, it follows that the space between the jetties would be rapidly deepened by the scour. The large increase of velocity in this profile can, of course, be obtained only by an additional head; that is, by a banking up of water back of the profile. It may be interesting to estimate, approximately, how much this banking up will amount to in the case under consideration.

If we call h the head, (height of fall necessary to produce a certain velocity, v,) we have

$$h = \frac{v^2}{64.4} = \frac{v^2}{8.025^2} \tag{1}$$

This, however, is a theoretical value, allowing nothing for loss of head by friction. According to Eytelweir, the factor $\frac{1}{8.025}$ should be increased to $\frac{1}{6.86}$ in cases where the stream is suddenly narrowed by bridge-piers, groyne, &c. Value h will then be

$$h = \frac{v^2}{6.86^2} = \frac{v^2}{47.07} \tag{2}$$

If the area of an average profile above the contraction by the jetties be called A, with a mean velocity v and a volume per second = Q; then

$$Q = A \times v \tag{3}$$

The same volume Q has to pass the area a of the contracted profile between the jetty-heads with a velocity v_1; therefore,

$$Q = a \times v_1 \tag{4}$$

and substituting this value of Q in (3),

$$Av = a \times v_1;\ v_1 = \frac{A}{a} \times v \tag{5}$$

$$\text{requiring a head} = \frac{v^2}{47.07} \times \frac{A^2}{a^2} \tag{6}$$

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But the water, when arriving, has already a velocity v, to which a head corresponds $=\frac{v^2}{47.07}$; the actual extra head or banking up required to produce the increased velocity v_1 will be, therefore,

$$\frac{v^2}{47.07} \times \left(\frac{A^2 - a^2}{a^2}\right) \qquad (7)$$

all expressed in feet.

The application of this formula would be very simple if there existed above the profile between the ends of the jetties something like a regular water-course between nearly parallel banks and nearly unchanging cross-section. As it is, Profile I is used, assuming that the general average of profiles between I and IV nearly corresponds to it. We obtain the following results:

Additional banking up, back of Profile IV = 1 inch, 1st quarter.
Additional banking up, back of Profile IV = 5.47 inches, 2d quarter.
Additional banking up, back of Profile IV = 6 inches, 3d quarter.
Additional banking up, back of Profile IV = 1.32 inches, 4th quarter.

This additional rise will not appear entirely and immediately in rear of Profile IV, as would be the case if there was a sudden contraction, as in the case of a river narrowed by the piers of a bridge, especially with the abutments reaching far into the river. Owing to the funnel-shaped direction of the jetties, the contraction is gradual, and the head will be more or less distributed. Now, if there were a uniform flow and discharge of water from a reservoir which receives as much per second as it discharges, this head would produce no other change than a decreased velocity in the portions of the water-course immediately above the contraction, compensated by the increased hydraulic mean depth caused by the banking up. Nothing will be changed in the volume discharged per second. But it will be different in the present case. The reservoir (Cumberland Sound, &c.) is steadily drained during the ebb-tide, with nothing to supply the loss except Saint Mary's River, &c., which during a great portion of the year will not add much to it. The rising of the water between the jetties to force a passage will, by occasioning a more gentle declivity up-streamward, cause a general diminution of velocity, most sensible in the second and third quarter ebb, where the water is banked up highest, and the consequence will most probably be a retardation in the outflow of the ebb. It would be of little use, however, to attempt a calculation of the length of this retardation, because the period will be continually modified by the incessant scouring of the bed between the jetties, until it has acquired a condition of comparative stability. A condition of stability can be supposed to exist in Profile I, where no material changes appear to have occurred since 1843. Whatever material may be there deposited is carried off again by the ebb-tide. If, by means of jetties, the whole volume flowing through Profile I is made to pass Profile IV, there is reason to expect similar results, after the scouring has produced such depths that the *mean velocities* with which the water passes are *about the same* as at Profile I, and Profile IV will then have attained its normal condition of stability. In attempting to estimate what depths will probably be found in Profile IV after the state of stability has been reached, it may be safer to assume that the velocities required to keep the channel free, and to sweep off the deposits as fast as they settle, should be somewhat larger than at Profile I, owing to the more exposed position of Profile IV. In the following table

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the calculations are based on the assumption that the bed will have reached its stability when the mean velocities are still about 10 per cent. higher than at Profile I.

TABLE C.—PROFILE IV, EBB.

Number of quarter.	Mean area.	Hydraulic mean depth.	Mean velocity per second.	Mean volume per second.
	Square feet.	*Feet.*	*Feet.*	*Cubic feet.*
First	140,100	35.25	1.09	152,708
Second	134,160	33.75	2.42	323,062
Third	128,220	32.25	2.39	304,656
Fourth	122,280	30.75	1.04	126,589

Mean depth at low water, 30 feet.
Area of cross-section at low-water, 118,650 square feet.

From the above depths and velocities, representing the state of stability at Profile IV, certain conclusions may be drawn by referring to Profile I. In that profile the proportion of general mean depth to the mean depth in the central portions of the water-way is as 21.33 feet to 36 feet, or as 1:1.7. The width of the deepest portion is 2,100 feet between 24-foot curves, or over one-third of the whole width. If similar proportions obtain at Profile IV, where the average low-water depth is, or will be, 33.75 feet, then the central portion of its water-way will have a hydraulic mean depth of 30 feet $\times$ 1.7 = 51 feet, which implies *maximum depths* at certain points where the current is strongest of from 60 feet to 70 feet. These great depths will rapidly decrease after the water has passed beyond the heads of the jetties, by spreading out on the bar. The longitudinal profile of the deep-water-current bed from the jetties seaward will have the form of an irregularly-ascending plane or slope. From its highest ridge there will be a reverse slope merging into the bed of the ocean. The question is whether the water, having left the jetties, will preserve enough strength of current to keep down that high ridge, with a proper width, to a depth sufficient for purposes of navigation. We know that the greater the velocity with which water leaves a conduit the smaller will be the divergence of its current-threads, and also that the greater the resistance of the medium through which the water flows and the friction of the bed, the more abrupt will be the lateral divergence. No rule is known of the ratio at which the water will spread over the bar, but an attempt may be made to arrive at an empirical solution of the problem by reasoning from analogy.

It has been stated that, as nearly as can be estimated from approximative calculations, 72 per cent. of the whole volume of ebb-tide passes at the present time through Profile II. Out of this amount 53.4 per cent. of the entire volume flows between the 24-foot curves of the same profile in a width of 1,406 feet. This 53.4 per cent., as it approaches and flows over the bar, spreads out, as shown by Figure 3, Plate III. A computation shows that south of this 53.4 per cent. of Profile II, just spoken of, about 11.6 per cent. flows over Kingsley's Bank. This 11.6 per cent. spreads over the shoals next to Amelia Island. We find this 11.6 per cent. again at Profile III, where it occupies a larger extent on the line of the profile than at Profile II. Laying off this distance on Profile III, we find next through what extent of the same the 53.4 per cent. of the deep-water course of Profile II flows; it will be found to occupy a length of 8,250 feet close up to the 6-foot curve of the north breakers. The mean distance between the two profiles is 5,300 feet. (See Figure 3, Plate III.)

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Assuming that the currents, on leaving the narrows between the jetties, would spread similarly to those passing from Profile II to Profile III, a profile taken at a mean distance from IV of 2,960 feet will then pass all the water that flows through the latter, provided it has a width of, say, 8,000 feet. This profile is located near the outer 18-foot curve of the bar, but on rather shallow shoals, its low-water depths ranging from 5½ to 10½ feet. At the present time the low-water area of the Profile V, Plate III, is 63,800 square feet, with a mean depth of 8 feet at low-water.

The same velocities that are supposed to correspond to a condition of stability at Profile IV will be assumed to produce approximately the same result at Profile V, but with different depths, owing to the expansion of the profile. The following table shows the calculated results, on the basis that equal bulks of water pass both profiles with nearly the same velocities per quarter.

TABLE D.—PROFILE V, EBB. (*See Plates II and III.*)

On outer slope of bar, near 18-foot curve. Width, 8,000 feet.

Number of quarter.	Mean area.	Mean depth.	Mean velocity per second.	Mean volume per second.
	Square feet.	*Feet.*	*Feet.*	*Cubic feet.*
First	149,200	18.65	1.02	152,708
Second	137,200	17.15	2.35	323,062
Third	125,200	15.65	2.43	304,656
Fourth	113,200	14.1	1.10	126,589

Mean depth at low-water = 13.4 feet.

Now, if similar relations obtain, as in Profile I, between the general mean depth and the mean depth in the deep-water channel, then the mean depth in the middle of Profile V will be something like $13.4 \times 1.7 = 22.75$ feet. Since this profile is somewhat back of the outer edge of the bar, the depths would probably be somewhat less at the imagined minimum-depth profile farther out. On the whole it would seem that, conceding the premises upon which these deductions rest to be tolerably correct, the herein-assumed disposition of full-height jetties *happens* to be about right for a 20-foot mean low-water channel on the bar for a distance of 2,960 feet beyond the heads of the jetties at B D, Plate II.

The stability of the northern border of the Amelia basin owes its existence not to any particular compactness of the shoals, but may be regarded as the result of an equilibrium of forces. The ebb-current issuing in full volume through Profile I, and having naturally an eastern direction as the resultant of the confluence of the Cumberland Sound and the Amelia River currents, has evidently the requisite power to sweep off and carry out about as fast as it is deposited, all the drift-sand that is brought in across the bar. When it has passed beyond the northeast point of Amelia Island, its volume expands over a larger area, and its scouring action on the south slope of the northern shoals diminishes, as may be seen by their more southerly trend from a point about opposite the northeast point of the island. If, therefore, the north shore of the island were artificially prolonged, by a jetty carried across the bar, this beneficial guiding action would be continued and a deep channel would be cut out over the bar. The line of comparatively steep slopes of the north shoals would then produce cross-sections in the outer reaches, with depths similar to those now existing in Amelia Basin.

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The foregoing discussion would appear to suggest that full-height jetties, extending to the crest of the present bar, and placed three-fourths of a mile apart at their heads, would create and keep open a channel about 20 feet deep for a distance of nearly 3,000 feet from the jetty-heads, but that beyond that distance, as the ebb-currents would have no scouring force, shoaling would take place, from any and all of the causes that have operated to form and maintain the present bar. By assuming a less width than three-fourths of a mile between the jetty-heads, the channel between would be deeper, and would be maintained for a great distance beyond. The danger of the jetties being undermined by the scour would be proportionately increased.

It must not be assumed that this channel beyond the jetty-heads will escape any of the vicissitudes to which the present bar-channel is subjected. The history of the bar, as already stated, shows that the main channel constantly moves to the southward; that while this movement is going on a new channel is being formed by the erosion of a pocket in the inner slope of the bar about due east from and in the prolongation of Amelia Basin; and that this pocket finally becomes a channel-way to the ocean, and the southern channel becomes extinct. When this takes place, the bar is restored essentially to the same condition in which it was found about forty years before. There seems no reason for supposing that the new bar, which will unquestionably form beyond the jetties, possibly 2 or 3 miles beyond, will be exempt from any of these changes, either in kind or degree. The new channel, instead of remaining in nearly one position on the prolongation of the deep-water line between the jetties, will bend to the south under the joint influence of the littoral ebb-current and the prevailing northeasterly storms, and after a time will form such an angle, with the general direction of the ebb-current between the jetties, that the latter will begin to eat its way through the bar on a line directly seaward, and will finally force a passage and form a channel on that line. The other outlet will then close up, and the movement will begin anew.

3.—*Stump jetties.*

Let us suppose that the jetties are each only one mile long, and located as shown on Plate II, at A E and F G.

I. *The north jetty*, on the line A B, will cut off Cumberland Channel and prevent the loss of ebb in that direction, so that the entire volume of outflow that now passes Profile I, over a width of 5,720 feet, will be caused to pass between the head of the jetty and Amelia Island, after the channel has become stable under its reduced width of about 3,000 feet at mean low-water. Until this stage is reached there will be an inward and an outward scour alternately, with a preponderance of the latter in aggregate effect, until a condition of equilibrium is established. In practice this state will be attained gradually as the construction of the jetty proceeds from the shore outward. We should then expect to obtain in the water-way abreast the head of the jetty a mean depth at low-water of about 40 feet, with 70 feet with upward in the deepest places. This supposes that the discharge through Profile I passes the new profile without retardation or banking up. In order to secure the full and continued benefit of this compact volume of outflow upon the bar beyond, it might be necessary to protect the end of Amelia Island from erosion at the point of greatest contraction. Otherwise there might be such a widening of the water-way, with a corresponding reduction in depth and divergence of flow, that the latter would fail to maintain its scouring power until it reached any of the shallow portions of the bar.

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If the jetty can be secured from under-washing by aprons, spurs, and deep foundations of the head, there will be a decided advantage in locating it on the line A E, or thereabouts, not only on account of the contraction of the current, which means a greater pushing power, but the direction of the jetty will also more effectually deflect the current-threads that now take Cumberland Channel. With less contraction than that indicated by the line A E, the ebb-current will more readily disperse over the north breakers after passing the jetty-head, with a corresponding diminution of the scouring value of the deep-water threads, upon which the efficacy of the method depends.

The divergence of the ebb over Pelican Shoal just east of the head of the jetty, located as that shoal is along the margin of the steep inner slope, will doubtless cause a removal of that shoal, or greatly increased depths upon it. This result will be aided by the flood-tide, which, having been shut off from Cumberland Channel, will flow with increased velocities around the head of the jetty, more especially after the shore-line of Cumberland Island shall have been moved out to that point by the accumulation of drift in the exterior angle. In other words, Cumberland Channel will be transferred to the present locality of Pelican Shoal, and that shoal will cease in great measure to perform, as it now does, the part of a training-wall. The result would be to diminish, prematurely, the volume of ebb in the main channel, and, therefore, impair its scouring power upon the bar beyond. To obviate this disadvantage Pelican Shoal should be maintained at its present height, which would be equivalent to the construction of a drowned jetty along its crest, in the prolongation of the full-height jetty from A to E, and of such length as the gradually-developed results would indicate to be necessary.

The subject of drowned jetties will be treated more at length hereafter.

2. *South jetty.* From the northern direction of the littoral-flood current it might be expected that if the south jetty be placed obliquely to it, as shown by the line F G, Plate II, the current striking its southern face would be gradually deflected and guided by it to the head, where it would enter the main channel with increased velocity. The same result would finally be obtained if this jetty were located more nearly at right angles with the shore, by the accumulation of drift against its exterior face, and the consequent extension of the shore-line to or near the point G. A somewhat violent scour, which would be of no benefit but rather a detriment to the main channel farther out, might be expected to take place around the jetty-head, suggesting the propriety of protecting the bottom by a submerged extension of the work, as already indicated for the Pelican Shoal at the end of the north jetty. By this device a sudden spreading of the volume of ebb, exterior to the high portion of the jetty, would be prevented, and its impetus and scouring power preserved for action upon the bar farther out.

The deepening of the channel abreast the head of the south jetty would probably be permanent, because by far the largest bulk of the ebb-tide would reach the bar in that direction, as being about in the prolongation of the deep-water axis of Amelia Basin.

The present ebb-current on leaving Amelia Basin has its strength soon exhausted by spreading out after getting beyond Amelia Island, and by being compelled to pass obliquely across the bar, which makes it travel a longer distance before it reaches deep water. This oblique direction is undoubtedly owing to the influence of the littoral ebb-current and other causes, such as dominating northeasterly winds and ensuing currents. This disadvantage will, to some extent, be remedied by the construction of stump jetties with submerged ends; the bulk of

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outflow will be brought in an unimpaired volume to a more advanced point of the present bar; and though it will likewise spread out laterally after getting beyond the head of the south jetty, it will have a shorter distance to travel across the bar.

The improvement that may be expected to be derived from such jetties may be approximately represented by figures as follows:

It has been shown that at ebb-tide 28 per cent. may be estimated to escape northward, between Profiles I and II, and 7 per cent. more between II and III, a total of 35 per cent. The larger half, or 18 per cent., will be found to flow out through the space that would be occupied by the high portion of the north jetty, and 17 per cent. over the submerged portion and the line of shoals down to Profile III. The volume of ebb, therefore, that will pass the end of the jetty at E will be greater by about 18 per cent. of the whole ebb than before the construction of the jetty. It may be assumed, perhaps, that after the contracted waterway has been deepened by the scour to a state of equilibrium no greater proportion of the ebb will escape over the north shoals between E and Profile III than at the present time, especially as Pelican Shoal, where the scour would doubtless be the greatest, is supposed to be protected by a submerged work. In this view of the case, 83 per cent. of the entire volume of ebb will pass through Profile III, instead of the present outflow of 65 per cent.

The construction of a south jetty, with its head at G, will prevent the spread of the ebb over the southern shoals to such a degree, that where at present 65 per cent. of the entire volume spreads out over the whole length of Profile III, (10,700 feet,) we may expect to have, as the joint result of both works, 83 per cent. flowing out through a width of only 2,700 feet.

This computation, as before stated, involves the questionable assumption that the north shoal maintains itself substantially in its present condition and continues to perform the part of a low training-wall as far out as Profile III.

Upon another page the mean volumes per second have been given that flow through Profile I, during each of the four quarters of ebb. See table, Profile I, ebb.

By multiplying each of these four average volumes by 0.83 we obtain the volumes expected, from the foregoing computation, to flow through the profile between the head of the south jetty and the nearest low-water shoal of the north breakers, a width of 2,700 feet, as follows:

Volume per second, first quarter..... $152,708 \times 0.83 = 126,747$ cubic feet.
Volume per second, second quarter..... $323,062 \times 0.83 = 268,141$ cubic feet.
Volume per second, third quarter..... $304,656 \times 0.82 = 252,864$ cubic feet.
Volume per second, fourth quarter ..... $126,589 \times 0.83 = 105,068$ cubic feet.

By means of the scour of the entering flood and that of the outflowing ebb, the bed of the bar will undergo material changes after the jetties have been built. If about the same velocities are applied to this profile that are expected to secure stability in Profile IV, the following table shows the result:

PROFILE G H, EBB.

Number of quarter.	Mean area.	Mean velocity.	Mean volume per second.
First	115,290	1.09 feet.	126,747 cubic feet.
Second	111,282	2.41 feet.	268,141 cubic feet.
Third	107,190	2.36 feet.	252,864 cubic feet.
Fourth	103,140	1.02 feet.	105,068 cubic feet.

Area of profile at mean low-water, 101,115 square feet; average depth at mean low-water, 37.45 feet.

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The *present* low-water area of this profile, considered as a part of the existing water-way, is 55,980 square feet, with a mean depth of 20.5 feet. Between 24-foot curves in a width of 960 feet it has an average depth of 28 feet. These dimensions are inferior, both as to area of cross-section and mean depth, to those it is anticipated will be there found after the jetties have been built, but they are considerable enough to invite some examination of the cause of their not exerting a stronger action on the bar.

The explanation seems to be that these eastern extensions of the basin are really the creation of unusually strong outward currents, caused by heavy freshets of Saint Mary's River and tributaries, in conjunction with high spring-tides and strong westerly winds. Such currents will work their way across the bar, plowing it up and scouring deepest in the direction of the longitudinal axis of greatest depths of Amelia Basin, until the increasing resistance of the bar exhausts their strength. The average ebb-tide derives no benefit from these deepened channels in such a sense as to continue the work, because, under existing conditions, there is nothing to prevent its spreading out after passing Kingsley's Bank, thus slackening its speed and destroying its scouring-power. By building the jetties the outflowing water is compelled to pass through a profile of limited extent, and the result will be an increase of velocity and scouring effect.

The next question is, to what distance forward from the head of the jetty will this strengthened current be able to cut a channel of sufficient depth, say 20 feet at mean low-water, without resorting to dredging? At the end of that distance a profile should be found of 20 *feet depth in the deep-water-portion* corresponding to a *general mean depth* of profile of 12 feet, according to the proportion

$$1.7 : 1 :: 20 : 12$$

approximately, as deduced from Profile I. In order to find at what distance from the jetty these depths will be found, with about the same velocities as given in Tables C, D, and E, which are presumed to correspond to a condition of stability, we refer again to Fig. 3, Plate III. Here we get the proportion

$$x : 1406 :: (x + 5300) : 8250'; \; x = \frac{1406\ (x \times 5300)}{8250} = 1074'.$$

This refers to profiles II and III. Similar ratios applied to the profile at the head of the south jetty of a width of 2,700 feet, (see Fig. 4, Plate III,) give

$$1074 : 1406 :: x : 2700; \; x = \frac{2700 \times 1074}{1406} = 2062 \text{ ft.}$$

This length of 2,062 feet may be regarded as a kind of radius of divergence, with which the profile at the jetty-head is described, and to which the advanced profile of 12 feet mean depth will be more or less concentric. To find this distance we must first find its probable area. This is determined approximately by taking a *mean* of the velocities at the four quarters of ebb, and a mean height between high and low water. The mean velocity will then be, (see Table E,)

$$\frac{1.09 + 2.41 + 2.36 + 1.03}{4} = 1.72 \text{ feet,}$$

and the mean height or depth $12' + 3' = 15$ feet. The average volume passing this advanced profile will be, (see Table E,)

$$\frac{126.747 + 268.141 + 252.864 + 105.068}{4} = 188.205 \text{ cubic feet.}$$

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If l represents the width of the advanced profile, then

$$15 \times 1.72 \times l = 188{,}205 \text{ cub. ft.}; \; l = 7{,}300 \text{ ft.};$$

and for the mean distance y between the two profiles we have the proportion

$$2060 : 2700 :: (y + 2060) : l; \; y = \frac{2060\ (l - 2700)}{2700} = 3500 \text{ ft.}$$

That is, after the current has reached the profile l, 3,500 feet distant from the jetty-head, it should still have sufficient strength to keep open a mid-channel of 20 feet, average low-water depth; but beyond that it rapidly loses its scouring power, and *dredging* will be required to provide for a ship-channel of that depth.

The *length* of channel to be *dredged* across the bar is 5,950 feet. To dredge a channel of that length, 300 feet wide at the bottom with $\frac{1}{2}$ slopes, and 20 feet depth at low-water, will require, according to the present condition of the bar, (survey of 1876,) the removal of nearly 680,000 cubic yards of material in addition to that brought in by the waves and currents during the progress of the work, of which no estimate worthy of much reliance can be formed. Its completion in less than two or two and a half years, operating with two powerful and thoroughly-equipped dredging steamers, could not be expected. The channel once established, could most likely be maintained for several years, by the constant service of one steamer, to depths varying from 18 to 30 feet, depending on the greater or less frequency and duration of damaging storms.

After some years—it is impossible to say how many—the channel-distance across the bar, by its extension beyond the limit of effective scour, which measures the length to be dredged, would become so great that one dredging-steamer would be inadequate to the work, and the annual expense would have to be doubled by putting on another boat; or perhaps the second one might be of less capacity, and therefore run at somewhat less expense than the first. Finally, when the bar shall have attained the limit of its growth seaward, the annual expense of maintenance would be sufficient to keep open a channel equally good across the present bar, unimproved by jetties, assuming such a channel to have been once established by dredging.

4.—*Full-length drowned jetties.*

The excessive depths required between the heads of high jetties in order to let in all the flood, unless they are placed so far apart as greatly to reduce the effective scouring-distance of the ebb-current outside, suggests that there might be great difficulty experienced in securing the works against destruction by undermining. The necessity for admitting the flood in unimpaired volume cannot be doubted. The consequences of reducing it are equally disastrous, whether it be the result of diminished water-way at the entrance, or diminished interior reservoir capacity. The reclamation of marsh-lands bordering the harbor by embankments which prevent the tide from overflowing them, is one of the most common methods of injuring the commercial value of harbors, of which many cases might be cited. We learn from Minard that in the harbor of Ostend a line of embankment or dike was constructed in 1626 which shut out the tide from a large area of previously submerged land. The result was that the harbor began to silt up, and finally the depth in the channel was reduced to a little over 3 feet. An opening was made

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in the dike in 1662, in order again to admit the tide upon the low lands, and the channel in 1698 had been scoured out to depths varying from 43 to 55 feet. The opening in the dike was closed in 1700, and in 1716 complaints began to be made that the channel was again shoaling by the deposit of silt, and in 1720 it became almost closed. Openings through the dike were again made to admit the tide, resulting in again scouring out the channel to a considerable extent, but the marsh-lands had by this time been filled in and raised to such a degree as greatly to impair their value as reservoirs, and the openings were subsequently closed up as useless. The silting up of the channel then continued, and in 1810 the depth had been reduced to about 6½ feet. The method of scouring by sluices was then resorted to, but without very satisfactory results.

The highest authorities on this subject concur in the necessity of providing for a free and full entrance of the flood-tide, and, if practicable, of augmenting its volume, in all projects for the improvement of tidal harbors, as otherwise the inevitable consequence will be a silting up of the channel, not only at the entrance, but in the inner reaches of the harbor. The useful depths of a stream for purposes of navigation, that is, the depths along the line of deepest water, are largely determined by the low-water flow. In a tidal stream it is the first of the flood and the last of the ebb which fix the location of the channel, and whose scouring action can be most easily and most surely controlled by concentration, for it is admissible to place the jetties or training-walls comparatively close together, if their crests are kept low enough to allow the water at its highest stages to pass freely over them.

It is also true that, having provided for the entrance of the largest possible amount of flood, then the greater the preponderance in volume of the ebb over the flood in the channel to be improved, the greater will be the benefits secured. As already stated, this preponderance in Fernandina Harbor comprises—

1. The land-drainage of 1,700 square miles.
2. The excess of flood over ebb passing through Cumberland Channel.
3. The water brought in by waves of translation over the shoals, which flows out as part of the principal or deep-water currents.

The jetties should be so designed that this preponderance shall be preserved. It may be possible to increase that derived from Cumberland Channel, as will be seen below.

The north jetty.—The location of the north jetty would be somewhere along the shoals forming the northern limits of Amelia Basin, the shore-end at some point on the south end of Cumberland Island, or on the line A B J, Plate II. As an average of the four quarters of flood, we have estimated the volume per second for Profile I at 199,982 cubic feet through an average profile half-way between high and low water, while Profile II passes 123,572 cubic feet per second. The difference, or 76,410 cubic feet, flows in from the northern breakers. To form an idea of the distribution of the latter volume, a profile was calculated from a point near Profile I, on Cumberland Island, across Cumberland Channel, and along the shoals to the north end of Profile II. The length of this profile is about 11,600 feet, of which 3,660 feet are shoals, bare, or nearly so, at low-water level. The depths of this profile range from 0 to 8½ feet at low water. By applying Downing's formula

$$V = 100 \times \sqrt{R \times S},$$

the velocities belonging to the varying depth-compartments were determined, which, multiplied with their respective areas, gave the vol-

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ume of 76,410 cubic feet per second. It was found that over the shoals, bare at low water on a length of 3,660 feet, 10,332 cubic feet per second pass into the basin, (about 3 cubic feet per linear foot of shoals;) and if the whole length (11,600 feet) were occupied by such shoals it might be concluded that only 32,746 cubic feet, instead of 76,410 cubic feet, per second would flow in. If the entire extent of line from I to III, a length of 16,200 feet, was formed of similar shoals, it might be expected that 45,732 cubic feet per second, or about 23 per cent. of the present total flood, would pass in over them, instead of the present flow of 45 per cent. (199,982—105,521=94,461 cubic feet.) The practical results would probably be somewhat different; for if we suppose a drowned jetty with its crest at mean low water to occupy the entire length of the north shoal from I to III, in conjunction with a south jetty, either full height or drowned, reaching to the crest of the bar, and that both are put in place suddenly, say at the slack-water of ebb, the first effects would be a violent inward scour between the jetty-heads and increased velocities over both jetties if the crests of both are kept low. There would be alternately an inward and an outward scour on the bar between the jetties, accompanied by a shortening of the periods of slack-water of both ebb and flood in Cumberland Sound, until a condition of stability was attained by the gradual deepening of the contracted water-way.

We should then expect a restoration to their normal condition of both the volume and duration of ebb and flood currents through Profile I. This supposition of a uniform height for the north jetty would eliminate the flood-tide character of Cumberland Channel, by destroying the preponderance in volume of its flood over its ebb. It would therefore deprive the project of whatever benefits might have been derived from this source, as contributing to the excess of outflow over the inflow in the main channel between and exterior to the heads of the jetties. The importance of preserving, and, if possible, increasing this excess suggests a modification of the foregoing design for the north jetty, by leaving Cumberland Channel open, for a time at least, and beginning the jetty in about 5 feet of water on the east side of that channel, thus leaving a gap about 2,400 feet wide next the shore. The idea is to close this gap partially at a later period by a continuous work adjusted to such height above the bottom as will give the largest ratio of preponderance of flood over the ebb. At the present time, according to calculation, out of 94,461 cubic feet per second passing in between Profiles I and III from the north, 33,574 cubic feet go over the site of the proposed gap. The gap having a length of 2,400 feet, the jetty, from its beginning near Pelican Shoal to Profile III, will have a length of 13,800 feet, (16,200 — 2,400.) The jetty with its crest at low water would then pass a volume of about 39,000 cubic feet per second $\left(\frac{45,732 \times 13,800}{16,200}\right)$. The balance, equal to 55,461 cubic feet per second, (94,461 — 39,000,) should pass the gap, instead of 33,574 cubic feet, as at present. The *existing* profile of the proposed site of the gap at half-tide possesses an area of cross-section equal to 20,491 square feet, with a wetted perimeter of 2,400 feet, a mean hydraulic depth at low water of 5.5 feet, and an average velocity of 1.64 feet per second. The building of the detached jetty will direct an average volume of 55,416 cubic feet per second through that profile, increasing the velocity to 2.7 feet per second $\left(\text{or}\frac{55,416}{20,491}\right)$ which, during the second half of flood, will rise to 3 or 4 feet. It will therefore produce considerable scour, resulting in an enlargement of the water-way by deepening, until a condition of stability

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has been reached. The increased volume would then flow in with about the present velocity through a profile having an area of about 33,786 square feet at half-tide, with a mean low-water depth of about 11 feet.

During this gradual approach to a stable profile, the water-way of the gap should be frequently gauged for both ebb and flood, in order to determine the conditions of profile corresponding to the maximum percentage of preponderance of flood over ebb. A submerged work should then be constructed across the gap, having its crest at such varying depths below the water-suface that a permanent profile representing those conditions will be established.

The preponderance of flood over ebb passing through the gap might be increased by a deflecting jetty, projected diagonally down stream from the inner shore of Cumberland Island, at the mouth of Beach Creek, as shown at S, Plate II. This jetty might have its crest at or above high water. It would not interfere at all with the entrance of the flood, or produce injurious eddies, while it would deflect the ebb-currents in Cumberland Sound away from the gap, and aid their exit by the main channel through Amelia Basin.

The north jetty will therefore be supposed to occupy the line of north shoals reaching from Cumberland Island to the outer 18-foot curve, the crest being established on a level of ordinary low-water, except for a length of 2,400 feet next the shore, where it is kept low enough to preserve the existing excess of flood over ebb in Cumberland Channel.

Between Profiles I and II about 28 per cent. of the entire volume of ebb, or an average of 63,218 cubic feet per second, passes out to the northward over a profile 11,600 feet long. According to calculation based on Downing's formula, out of this volume of 63,218 cubic feet, 8,698 cubic feet per second passes over the length of 3,660 feet of shoals just bare at low-water.

If a jetty, having its crest on the level of these shoals or mean low-water, occupied their entire length of 16,200 feet from Cumberland Island to the north end of Profile III, then the proportionate amount flowing over it should be 38,500 cubic feet per second, since

$$3{,}660 : 8{,}698 :: 16{,}200 : 38{,}500$$

that is, 38,500 cubic feet, or 17 per cent., would escape, where now 79,048 cubic feet, or 35 per cent., is lost; a gain of 18 per cent. for the main channel. The variation from this result, due to the lower level of the work across Cumberland Channel, will be assumed to be beneficial, for reasons already given.

A drowned south jetty, with its crest not higher than mean low-water level, located on line C Q, Plate II, will have a length of about 12,800 feet from its shore-end on Amelia Island to the outer 18-foot curve. With the north jetty placed as above described, there will be a width of half a mile between jetty-heads, and a volume of nearly 60 per cent. of the whole ebb-flow will pass out between them. In this case the method of calculation employed in estimating the probable effects of the jetties previously discussed, determines the distance seaward of the jetty-heads, at which the scouring-power of the currents will be able to maintain a mid-channel low-water depth of 20 feet, to be 3,900 feet.

If the width between jetty-heads be reduced to 2,000 feet, the general average depth should be about 35 feet, after a state of comparative permanence in the contracted water-way has been reached. This would imply a mean depth of about 68 feet in the central portion, with maximum depths of perhaps 80 feet, and a power to maintain a channel 20

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feet deep at mean low-water for a distance of 5,200 feet, or nearly one mile beyond the heads of the jetties.

By narrowing the width still more, say to one-fourth of a mile, or 1,300 feet, the scour will produce an average depth of perhaps 54 feet, with a mean depth in central portion of something like 90 feet, and maximum depths of over 100 feet. The current will probably preserve a scouring power sufficient to maintain a channel of 20 feet depth at low-water for a distance of something over 1½ miles beyond the jetties.

5.—*Full-length drowned north jetty and full-height south jetty.*

With a drowned north jetty located precisely like that just discussed, and a full-height south jetty, placed as shown by line C Q, Plate II, running out to the outer 18-foot curve of the bar, a larger amount of the ebb will be caused to flow out between the jetty-heads than in the case just considered. According to previous computations, we may expect over 80 per cent. of the whole ebb-flow of Profile I to pass out between the jetty-heads. The action of the issuing current will be, therefore, more energetic, resulting in a comparative lengthening of the channel produced by it beyond the jetty-heads. The method of calculation heretofore adopted gives the following results for the case under consideration:

For a width between jetty-heads of half a mile, a channel of 20 feet depth at low-water will extend beyond the jetty-heads about 5,500 feet; for a width between jetty-heads of 2,000 feet, the channel will have a length of 7,000 feet; and for a width of 1,300 feet, the exterior length may be over two miles. The depth between jetty-heads will, of course, increase in a corresponding ratio.

THE DURATION OF THE IMPROVED CHANNEL.

The value or duration of the benefits to be derived from the use of jetties for the improvement of a bar-channel which forms the outlet of a tidal non-sedimentary stream is largely a matter of conjecture, more especially when the bar, as in the case under consideration, has not formed the subject of careful and prolonged study made with special reference to contemplated works of improvement. The records of the most elaborate hydrographic survey, even if annually repeated, would be largely wanting in the kind of information required by the engineer in designing his project; for such surveys and the charts resulting from them, although they might be everything that could be desired by navigators and seamen, and would furnish an accurate history of the changes taking place in the location and form of the bar, *would give no measure of the quantity of material moved in effecting those changes.* While it is true that no alteration of the physical features of the bar could take place without a movement of materials, it is equally true that many hundreds of thousands of cubic yards of silt and sand might be moved again and again from one side of the bar-channel to the other without forming an integral part of the hydrographer's observations, and even without being recognized by him at all, although caused by storms occurring at intervals during the progress of his work.

For example, a heavy northeasterly storm, producing breakers along the north shoal from Cumberland Island to Profile III, a distance somewhat exceeding 3 miles, would throw up large quantities of sand, carry it over the crest of the shoal, and drop it in the deep water of the main channel between Profiles I and III.

It would next be taken up by the ebb-currents, and rolled or carried

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out toward the sea until it encountered the littoral ebb-current, accelerated by the storm, by which it would be again moved in a southwesterly direction, and finally left to the action of the south breakers, which would distribute it upon the south shoal. This action, which is illustrated in Figure 5, Plate III, would be incessant during the continuance of the storm, every wave upon both the north and south shoal doing its part of the work. The results will be (1) to lower the north and correspondingly raise the south shoal, and (2) move the outlet of the bar-channel to the southward.

The action of a southerly storm will be the reverse of this, moving the material from the south to the north shoal. I am not aware of any experiments having been made by means of which an estimate can be formed of the quantity of material that would probably be transported from one side of the channel to the other, in a given time, by the agency of a heavy storm. As a moderate assumption, a northeaster, of three days' duration, might be expected to lower the north shoal 4 inches within the area covered by the breakers. The greater part of the eroded material, amounting to upward of 516,000 cubic yards, would doubtless be distributed along the south shoal during the progress of the storm. If the waves should subside, or a southerly or southeasterly storm set in before the bar-channel had returned to its normal condition, the material subsequently carried out would not reach the south shoal, but in the former case would remain near the outlet on the outer slope of the bar, and in the latter would be carried back by the waves to the north shoal. If as much as one-fourth of it remained in the bar-channel between the inner and outer 18-foot curves, a few severe storms, such as frequently occur within the period of a single month, would entirely destroy it by filling it up to the level of the shoal on either side.

It would appear, therefore, that millions of cubic yards of the material composing the bar might be shifted back and forth from one side of the channel-outlet to the other during a single season, without causing injury to the channel by shoaling, and without producing any changes in the form and location of the bar itself, that might not entirely escape the notice of the most careful surveyor. And yet this shifting of material, of which no evidence may be left behind, should enter as an important if not a controlling function in the project of the engineer, because the useful life of his works is more or less dependent thereon.

When the shoal on either side is occupied by a jetty, new and important conditions are interposed, for the sand cannot be carried into the main channel by means of translation, until it has filled in and banked up as high as the crests of the works on the outside. If the works rise much above the level of high water, its passage into the main channel will be arrested entirely, until its accumulation on the exterior carries the shore-line to or near the heads of the jetties. After this it will drift in around the ends, to be subsequently taken up and carried out by the ebb-currents, and finally deposited on the leeward shoal.

If the jetties do not rise above the level of high water, the sand will be carried in by storms over their crests, as soon as it shall have accumulated to that height on the outside. It will also pass in around their ends, to be carried out and deposited on the leeward section of the bar, as before.

With regard to jetties with their crests located above the level of high-water, whether full length or otherwise, very little reliance should be placed upon any estimate of the time that would probably elapse before the shore-line would be advanced to the vicinity of the jetty-heads by the accumulation of sand in the exterior angles. Perhaps

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eight or ten years would suffice to produce this result, even if the works reach to the outer 10-foot curve. After this the material would be drifted into the channel around the jetty-heads by every heavy storm striking the shore obliquely; the ebb-scour would take it up and carry it farther out, where it would be disposed of either near the channel-outlet, or upon the north or south shoal, depending on the force and direction of the waves prevailing at the time. In this manner the bar would grow seaward throughout its entire arc, the extent of its final growth under the new conditions being proportioned to the length of the jetties.

It is believed that full-height jetties are not the most suitable kind for the improvement of the entrance to a tidal harbor in which the preponderance of the outflow over the inflow is no greater than it is at Fernandina. They necessitate either a wide opening or excessive depths between the jetties, to insure the necessary filling of the tidal reservoir at each flood. The former condition implies a reduction in the outward reach of the effective scour, and the latter increased doubt in the practicability of building the works and securing them from destruction by undermining.

Low jetties, besides being less costly, would give better results than high ones, and in constructing them their crests should not be placed above the low-water level. They might afterward be gradually raised higher from the shore outward, if deemed necessary or desirable.

ESTIMATES OF COST.

1. FULL-HEIGHT JETTIES EXTENDING ACROSS THE BAR.

The north jetty, running on the line A B J, Plate II, would have a length of 21,120 feet, of which 15,840 feet are supposed to be a gabionage in two tiers of single rows, and the outer or bar end a length of 5,280 feet, a riprap formation.

North jetty.

15,840 linear feet gabion jetty, at $10.42	$165,052 80
8,400 linear feet spur jetty, at $5.21	43,764 00
160,000 cubic yards riprap, at $6	960,000 00
30 per cent. contingencies, including settling	350,645 04
	1,519,461 84

If the whole jetty were built as a riprap dam, it would require 434,000 cubic yards, and the cost would be—

434,000 cubic yards, at $6 per yard	$2,604,000 00
30 per cent. for contingencies, including settling	781,200 00
	3,385,200 00

The south jetty, running on the line C D M, would have a length of 13,050 feet, of which only 1,150 feet would be built of gabions, and 11,900 feet of riprap.

South jetty.

1,150 linear feet gabion jetty, at $10.42	$11,983 00
600 linear feet spur jetty, at $5.21	3,126 00
432,000 cubic yards riprap, at $6	2,592,000 00
30 per cent. for contingencies, including settling	782,132 70
	3,389,241 70

The whole south jetty in riprap would cost—

440,500 cubic yards riprap, at $6	$2,643,000 00
30 per cent. for contingencies	792,900 00
	3,435,900 00

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SUMMARY.

North jetty, part riprap and part gabion	$1,519,461 84
South jetty, part riprap and part gabion	3,389,241 70
Total	4,908,703 54
North jetty, all riprap	$3,385 200 00
South jetty, all riprap	3,435,900 00
Total	6,821,100 00

2. FULL-HEIGHT JETTIES REACHING TO THE CREST OF THE BAR.

In this case the heads of the jetties are supposed to be so located that the issuing current preserves sufficient strength to secure a channel of not less than 20 feet depth at mean low water, without resorting to dredging.

The north jetty, located on line A B, Plate II, will have a total length of 17,200 feet, of which 1,360 feet would be riprap, and the balance gabion jetty.

North jetty.

15,840 linear feet gabion jetty, at $10.42	$165,052 80
8,490 linear feet spur jetty, at $5.21	43,764 00
58,000 cubic yards riprap, at $6	348,000 00
30 per cent. contingencies	167,043 84
	723,860 64
If this work were built entirely of riprap, it would cost—	
332,000 cubic yards, at $6	$1,992,000 00
30 per cent. contingencies	597,600 00
	2,589,600 00

The south jetty, on the line C D, has a length of 7,865 feet, of which 1,150 feet would be built of gabions.

South jetty.

1,150 linear feet gabion jetty, at $10.42	$11,983 00
600 linear feet spur jetty, at $5.21	3,126 00
231,800 cubic yards riprap, at $6	1,390,800 00
30 per cent. contingencies	421,772 70
	1,827,681 70
Built entirely of riprap, it would require—	
240,300 cubic yards, at $6	$1,441,800 00
30 per cent. contingencies	432,540 00
	1,874,340 00

SUMMARY.

North jetty, part riprap and part gabion	$732,860 64
South jetty, part riprap and part gabion	1,827,681 70
Total	2,560,542 34
North jetty, all riprap	$2,589,600 00
South jetty, all riprap	1,874,340 00
Total	4,463,940 00

3. STUMP JETTIES, ABOUT ONE MILE LONG EACH.

This mode of improvement will comprise the construction of the following works:

a. North jetty, one mile long.

b. Drowned jetty to re-enforce Pelican Shoal on a length of about one mile.

c. Protecting north shore of Amelia Island by means of spur jetties.

d. South jetty, about one mile long.

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a.—North jetty.

This jetty would extend from Cumberland Island to a point near Pelican Shoal, on line A E, Plate II. The average depth now found on this line is less than 6 feet; but the estimate is based on the assumption that two tiers of gabions 6 feet high are required on the whole line.

5,280 linear feet gabion jetty, at $10.42	$55,017 00
2,800 linear feet spur jetty, at $5.21	14,588 00
30 per cent. contingencies	20,881 68
	90,487 68

Built entirely of riprap it would require—

88,000 cubic yards, at $6	$528,000 00
30 per cent. contingencies	158,400 00
	686,400 00

b.—Drowned jetty for Pelican Shoal.

This jetty would have its crest at mean low-water level; at its western end it will connect with the head of the north jetty and follow the line of Pelican Shoal for a length of one mile. This jetty will be supposed to be made entirely of riprap, and would require—

12,500 cubic yards, at $6	$75,000 00
30 per cent. contingencies	22,500 00
	97,500 00

c.—Protecting north shore of Amelia Island.

About six spur jetties are estimated to be required extending from the shore to the 6-foot curve; their shore-ends to be raised to high-water level, and their heads to be kept at low-water mark, so that their crests incline toward the channel. Their aggregate length would be about 1,200 feet.

1,200 linear feet gabion jetty, at $5.21	$6,252 00
Riprap apron around jetty-heads	1,000 00
30 per cent. contingencies	2,176 00
	9,428 00

If built entirely of riprap they would cost $24,000.

d.—South jetty.

Extending from east shore of Amelia Island in a northeasterly direction, a length of 5,600 feet on line F G, Plate II. Of this length 3,900 feet may be built with gabions, and 1,700 feet as riprap dam.

3,900 feet (linear) gabion jetty, at $10.42	$40,638 00
2,600 feet (linear) spur jetty, at $5.21	13,546 00
103,360 cubic yards riprap, at $6	620,160 00
30 per cent. contingencies	202,303 20
	876,647 20

Built entirely of riprap it would require—

177,400 cubic yards, at $6	$1,064,400 00
30 per cent. contingencies	319,320 00
	1,383,720 00

The employment of stump jetties will necessitate dredging on the bar, amounting to the removal of 680,000 cubic yards for a channel of 20 feet depth at low-water, and 300 feet width at bottom.

Dredging 680,000 cubic yards, at 25 cents	$170,000 00
First cost of steam-dredge	75,000 00
$7,500 or 10 per cent. of first cost for wear and tear, and $25,000 for running-expenses and ordinary repairs, capitalized at 5 per cent	650,000 00
	895,000 00

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SUMMARY.

A.—*Mixed system.*

North stump jetty	$90,487 28
Pelican shoal, re-enforced	97,500 00
Amelia Island, re-enforced	9,428 00
South jetty	876,647 20
Dredging	895,000 00
Total	1,969,262 48

B.—*Entirely of riprap.*

North stump jetty	$686,400 00
Pelican Shoal, re-enforced	97,500 00
Amelia Island, re-enforced	24,000 00
South jetty	1,383,720 09
Dredging	895,000 00
	3,086,620 00

4.—DROWNED FULL-LENGTH JETTIES.

a.—North jetty.

Located on line A B J, Plate II, following, more or less, the line of shoals north of Amelia Basin. Total length, four miles. Cumberland Channel to be left open to a length of 2,400 feet, the bed being re-enforced with riprap. An adjoining length of 13,440 feet may be built of a single row of gabions 6 feet high, while the outer one-mile length on the bar should be riprap. A deflecting jetty is also thought necessary at the mouth of Beach Creek to guide the ebb-flow toward the deep water of the entrance of Cumberland Sound. Its length will be about 3,200 feet, reaching to about 15 feet depth at low-water. It may be built either with a riprap foundation, and a gabionage on top, or entirely of riprap.

3,600 cubic yards riprap, re-enforcing Cumberland Channel	$21,600 00
13,440 linear feet gabion jetty, at $5.21	70,022 40
4,500 linear feet spur jetty, at $5.21	23,445 00
71,500 cubic yards riprap for outer mile, at $6	429,000 00
3,200 feet deflecting jetty, full height, at $20	64,000 00
30 per cent. contingencies	182,419 22
	790,486 62

Built entirely of riprap it would require—

123,000 cubic yards for main jetty, at $6	$738,000 00
35,700 cubic yards for deflecting jetty, at $6	214,200 00
30 per cent. contingencies	285,660 00
	1,237,860 00

b.—South jetty—(drowned.)

Located on line C Q it would have a length of 12,750 feet, of which 3,500 linear feet may be built of gabions, which would require to be placed in one tier for a length of 2,300 feet, and in two tiers for a length of 1,200 feet. The outer portion should be riprap a length of 9,250 feet.

2,300 linear feet gabion jetty, one tier, at $5.21	$11,983 00
1,200 linear feet gabion jetty, two tiers, at $10.42	12,504 00
1,800 linear feet spur jetty, at $5.21	9,378 00
126,000 cubic yards riprap, at $6	756,000 00
30 per cent. contingencies	236,959 50
	1,026,824 50

Built entirely of riprap there would be required—

152,000 cubic yards, at $6	$912,000 00
30 per cent. contingencies	273,600 00
	1,185,600 00

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SUMMARY.

A. Mixed system, part gabion and part riprap:

North jetty and minor works	$790,486 62
South jetty	1,026,824 50
Total	1,817,311 12

B. Entirely riprap:

North jetty and minor works	$1,237,860 00
South jetty	1,185,600 00
Total	2,423,460 00

5.—FULL-LENGTH DROWNED NORTH JETTY AND FULL-HEIGHT SOUTH JETTY.

a. The estimate for the north jetty would be the same as above.

b. The south jetty, located as above, will have a length of 13,350 feet from Amelia Island to the outer 18-foot curve. About 3,000 feet of the shore-end may be built of a double-tier gabionage, the balance riprap.

3,000 linear feet gabion jetty, at $10.42	$31,260 00
1,600 linear feet spur jetty, at $5.21	8,336 00
374,000 cubic yards riprap, at $6	2,244,000 00
30 per cent. contingencies	685,079 00
	2,968,675 00

Built entirely of riprap it would require—

420,000 cubic yards, at $6	$2,520,000 00
30 per cent. contingencies	756,000 00
Total	3,276,000 00

SUMMARY.

North jetty, gabion and riprap	$790,486 62
South jetty, gabion and riprap	2,968,675 00
Total	3,759,161 62
North jetty, all riprap	$1,237,860 00
South jetty, all riprap	3,276,000 00
Total	4,513,860 00

The papers sent to me for my information, consisting of official reports, or extracts therefrom, made between the years 1839 and 1861, are for the most part, and with a single exception, discussions from a military or naval point of view, setting forth the value of the harbor of Fernandina as a place of refuge for our merchantment in time of maritime war, or as a site for a military or naval depot.

The necessity of protecting it by fortifications, in order that it may be securely available for such purposes, is clearly stated; and the arguments employed are both strong and familiar, although the lapse of time has deprived some of them of their original pertinence and force.

None of them, however, recommend or contemplate the improvement of the harbor or its channel of approach by artificial means, and their relations to the commercial questions suggested by the Senate resolution are, therefore, in a great degree inferential.

The argument based upon the fitness of the place for a military or naval depot, may properly be left in abeyance until the question of its selection for such purpose is affirmatively determined; when the magnitude of the improvements, should any be necessary, may be intelli-

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gently adjusted to the requirements of the largest class of vessels that are to be accommodated.

Such a contingency seems unlikely to arise with respect to a naval depot at least, as the Government already owns an excellent site for such an establishment in Saint Simon's Sound, less than 30 miles distant. The question of enlarging its channel of approach in order to enhance its value as a harbor of refuge from storms, or even from hostile men-of-war, should be considered in connection with other harbors in its vicinity, or on the coast of Georgia. The late Chief Engineer of the Army, General Totten, in a report on sea-coast defenses made to the Secretary of War in November, 1851, referred to Fernandina Harbor as "the best and deepest of these Georgia entrances;" an opinion which, like some of those advanced in the papers sent to me, was doubtless based upon partial if not inaccurate information. The completion of the surveys of the principal harbors upon that portion of our coast, places an estimate upon their relative value somewhat differing from that entertained twenty-five years ago. This will be seen by reference to the following list, arranged in regular order from south to north. It has been prepared from the published charts of the Coast Survey establishment. The depths given are those of the shoalest part of the channel of entrance along its center line:

	Mean low-water depth.	Mean rise and fall of tide.
	Feet.	*Feet.*
Cumberland Sound, Fernandina Harbor; ample anchorage..... { usually / now	13 / 11	5.9
Saint Andrew's Sound, 17½ miles from Fernandina; good anchorage	16	7.1
Saint Simon's Sound, 28½ miles from Fernandina; ample anchorage	17	6.8
Altamaha Sound, 42½ miles from Fernandina; limited anchorage	11	7.0
Doboy Sound, 47½ miles from Fernandina; ample anchorage	14	7.0
Sapello Sound, 62 miles from Fernandina; ample anchorage	18	6.6
Saint Catharine's Sound, 73 miles from Fernandina; good anchorage.....	13	7.3
Ossabaw Sound, 78 miles from Fernandina; ample anchorage	14	7.7
Warsaw Sound, 90 miles from Fernandina; ample anchorage	14	7.7
Savannah River, 103 miles from Fernandina; ample anchorage	18½	7.0

The practicable depth in the Fernandina entrance is unusually shallow at the present time, owing to the existence of a narrow secondary bar lying directly across the bar-channel, which is not shown on any former survey. It is probably only a temporary obstruction, which will disappear in time under the constant changes and fluctuations to which the bar is subjected. Its removal to a low-water depth of 13 feet with the Government dredging-steamer now employed on the Savannah River would not cost more than $10,000 to $12,000; but it would probably reform as often as removed until the bar assumed such shape and the currents such directions as would remove a tendency to deposit at that point.

There are, therefore, not less than six harbors on the Georgia coast that have a deeper channel of entrance than Fernandina usually possesses.

Of these the two that lie nearest to Fernandina (Saint Andrew's, 17½ miles, and Saint Simon's, 28½ miles distant) have bar-channels that are very nearly straight, while the Fernandina Bar is somewhat difficult to navigate, especially in stormy weather, on account of its crooked entrance.

As a harbor of refuge, therefore, whether from the dangers of the sea or from hostile cruisers, Fernandina cannot be said to possess any great

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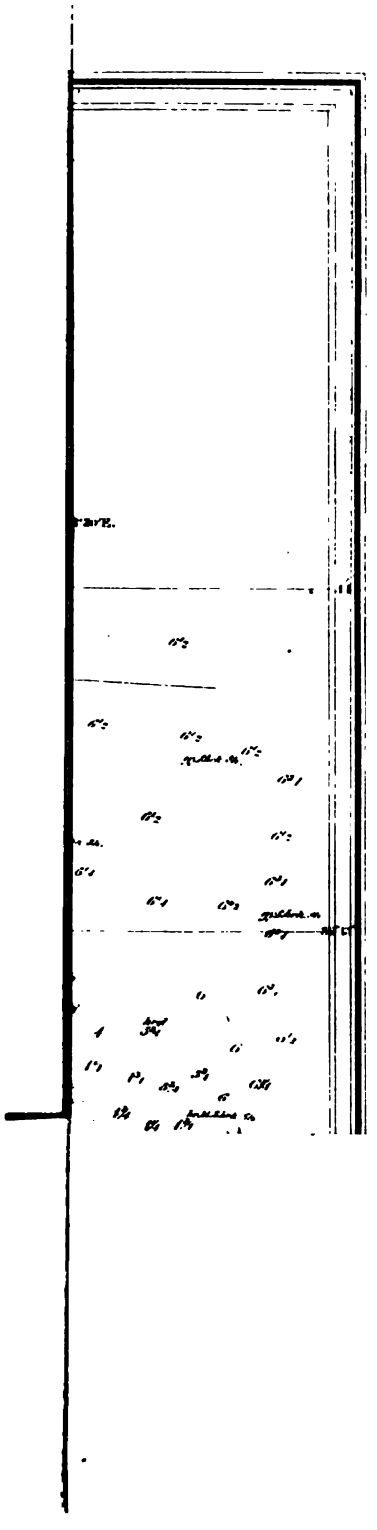

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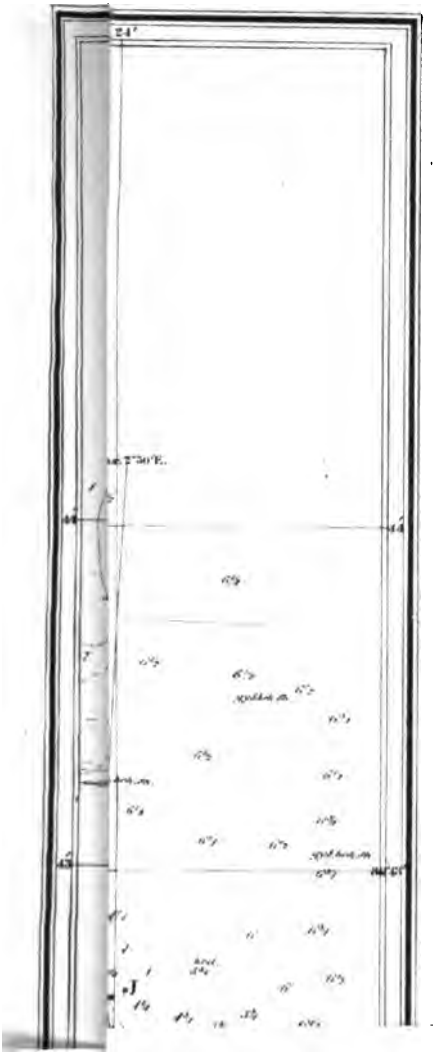

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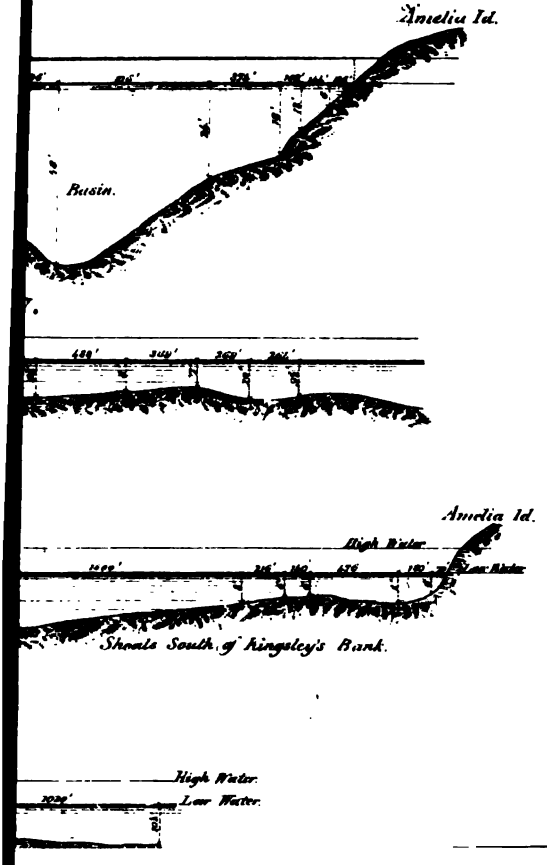

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or special advantages on account of its locality, while its inferiority in channel-depth is marked and positive.

In considering the commercial importance of Fernandina Harbor, present and prospective, as an avenue for foreign and domestic trade, the questions which present themselves are somewhat more problematical than those already referred to. An estimate of the magnitude to which its commerce would grow, provided the harbor were made permanently accessible to the larger class of ocean-going vessels, must be largely conjectural, and I am not prepared to enter upon it at the present time. I am unable to discover any elements of commercial superiority, plainly attributable to the position of the place, that would seem to justify the General Government in undertaking, at the present time, the construction of costly works for the accommodation of a trade that does not exist, and which cannot be expected to spring up in the immediate future.

A statement of the number, tonnage, and crews of vessels engaged in the foreign and coastwise trade which entered and cleared the port of Fernandina from the year 1870 to the year 1874, inclusive, has been furnished to me by the collector of customs of that port, and is hereunto appended.

An appropriation of $12,000 is recommended, to be applied to deepening the channel across the bar to its usual depth of 13 feet at mean low-water.

Three plates, numbered respectively Plate I, Plate II, and Plate III, accompany this report.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Col. of Engineers, Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

ARRIVALS AND CLEARANCES OF VESSELS AT THE PORT OF FERNANDINA, FLA., FROM 1870 TO 1874, INCLUSIVE.

Vessels entered.

Year.	Coastwise.			American vessels from foreign ports.			Foreign vessels from foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1870	275	139,186	6,368	9	1,220	32	5	980	37	289	141,395	6,437
1871	266	136,453	5,808	14	2,917	99	4	779	31	284	140,149	5,938
1872	230	122,781	4,944	22	5,753	177	15	4,709	157	267	133,243	5,278
1873	207	97,250	3,822	22	5,056	164	26	7,828	266	255	110,134	4,252
1874	212	105,978	3,999	28	7,208	210	23	7,242	228	263	120,428	4,437
Aggregate	1,190	601,648	24,941	95	22,163	682	73	21,538	719	1,358	645,349	26,342

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Vessels cleared.

Year.	Coastwise.			American vessels to foreign ports.			Foreign vessels to foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1870	251	134,977	6,216	21	5,661	184	4	892	32	276	141,530	6,432
1871	263	134,276	5,736	29	6,496	189	12	3,649	102	304	144,421	6,027
1872	213	112,703	4,610	24	6,587	184	27	8,774	278	264	128,064	5,072
1873	203	92,866	3,731	29	7,345	213	40	14,650	399	272	114,861	4,343
1874	218	106,849	4,041	33	8,727	257	27	8,584	260	278	124,160	4,558
Aggregate	1,148	581,671	24,334	136	34,816	1,027	110	36,549	1,071	1,394	653,036	26,432

Exports.		Imports.	
Year.	Value of exports.	Year.	Duties collected.
1870	$122,525	1870	$5 00
1871	156,015	1871	38 82
1872	232,239	1872	42 96
1873	373,059	1873	550 66
1874	300,135	1874	569 67
Total	1,183,973	Total	1,207 11

H 7.

INSIDE PASSAGE BETWEEN CUMBERLAND SOUND AND SAINT SIMON'S SOUND, GEORGIA.

UNITED STATES ENGINEER-OFFICE,
New York, April 24, 1876.

GENERAL: I have the honor to acknowledge the receipt of a letter from the office of the Chief of Engineers, dated March 23, 1876, referring to me for report the following resolution of the Senate of the United States, viz:

IN THE SENATE OF THE UNITED STATES,
March 16, 1876.

Resolved, That the Secretary of War be, and is hereby, requested to communicate to the Senate his opinion as to the importance and practicability of deepening the inside passage between Cumberland Sound and Saint Simon's Sound, State of Georgia, with estimates of the probable cost of such improvements in connection with any contemplated improvement of the inside passage between Fernandina and the Saint John's River.

Attest:

GEO. C. GORHAM,
Secretary.

The entire length of this passage from the wharf at Fernandina to Saint Simon's Sound may be estimated at 38 miles, and comprises the following water-courses:

Commencing at Fernandina, the route takes the lower portion of Amelia River to the mouth of Cumberland Sound, a length of 3 miles, with a wide channel and water deep enough for any class of vessels; thence it runs up Cumberland Sound, which is subdivided at several places into branches by mud islands. Up to the "Divides," or head of Cumberland Sound, the main channel has a minimum depth of 13 feet at low-water, with long reaches of more than 20 feet depth.

"Crooked River" discharges into the sound by two branches, and it is at the mouth of the northern branch that the tides of Cumberland

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and Saint Andrew's Sounds meet and cause shoaling. The shoals at this point will have to be removed by dredging, which operation will require to be repeated from time to time. The "Divides" are 9½ miles from the entrance of Cumberland Sound.

A little to the north of the "Divides" the sound separates into two branches, called respectively Cumberland River and Brickhill River. The latter has comparatively good water in its channel-way, varying from 10 to 36 feet, with shoals of from 6 to 7 feet depth at mean low-water. It is, however, narrow and tortuous. Cumberland River, at a distance of about 3½ miles from the "Divides," forms a bend of nearly 90°; thence it runs in a nearly straight line to Saint Andrew's Sound, having been rejoined by the Brickhill River about 3 miles from the bend. The shallowest places of the Cumberland River appear in the reach from the "Divides" to the bend, where the proof-sheet of the latest coast-chart (No. 57) indicates depths in some parts of the channel-way ranging from 7 to 11 feet. The width of the river, between high-water shore-lines, is 250 yards at the narrowest point.

On the whole, this river shows good depths, from 14 feet up to 36 feet and more, the deep channel being rather narrow, however, in some places, especially in the southern branch of the bend.

The whole length of the inside passage between Fernandina and Saint Andrew's Sound may be reckoned at 26 miles. On the greater part of this length it is sheltered from the ocean by Cumberland Island, which is upward of 18 miles long.

From Saint Andrew's Sound the passage leads through Jekyl Sound into Jekyl Creek, with depths of water ranging between 12 and 42 feet, to within 1½ miles of its junction with Brunswick River. The width of Jekyl River ranges generally from 400 to 600 yards, except in the last northern reach, where it narrows to from 90 to 100 yards. This reach would require dredging, if the establishment of a channel of 6 feet depth at low-water be desired. There are also rather extensive shoals at the mouth of Jekyl Creek; the distance from that mouth to the nearest point of the 6-foot curve of Brunswick River being 550 yards, over which the low-water depths vary from 2½ to 6 feet.

The length of the inside passage from Saint Andrew's to Saint Simon's Sound, by way of Jekyl Creek, is about 12 miles. This route is shut off from the sea by Jekyl Island, which has a length of nearly 8 miles from south to north.

To obtain a channel from Fernandina to Saint Simon's Sound, that should have a minimum depth at mean low-water of 6 feet and a width at the bottom of 100 feet, will require dredging at three places:

1st. At the "Divides" at the head of Cumberland Sound. Amount of dredging, 9,000 cubic yards.

2d. Shoals about 1 mile south of the junction of the eastern branch of Jekyl Creek with Brunswick River. Estimated quantity of sand to be removed by dredging, 8,000 cubic yards.

3d. The mouth of Jekyl Creek and the channel leading across the shoals to Brunswick River will have to be deepened by the removal of about 15,000 cubic yards.

ESTIMATE OF COST OF ESTABLISHING CHANNEL.

Dredging 9,000 cubic yards at the "Divides," at 25 cents per yard	$2,250
Dredging 8,000 cubic yards near mouth of Jekyl Creek	2,000
Dredging 15,000 cubic yards at and beyond mouth of Jekyl Creek	3,750
Twenty per cent. for contingencies	1,600
Total	9,600
Or say	10,000

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Dredging will probably be required annually to maintain the channel at two of the above-named places, viz, at the "Divides," where the meeting of the tides will be a constant cause of shoaling, and at the mouth of Jekyl Creek.

Estimating the cost of annual dredging at 15 per cent. of the total cost of establishing the channel, $1,500 per annum will be required, one-half of which may have to be applied at the "Divides" and the other half at the mouth of Jekyl Creek.

The Senate resolution requires this question to be considered "in connection with any contemplated improvement of the inside passage between Fernandina and the Saint John's River." It is presumed that reference is here made to the project submitted by me June 14, 1875, in which estimates were given for a channel of 11 feet and for one of 13 feet depth at high-water, as follows:

No. 1 channel, 125 feet by 13 feet high-water	$370,000
No. 2 channel, 125 feet by 11 feet high-water	265,000
No. 3 channel, 80 feet by 13 feet high-water	225,000
No. 4 channel, 80 feet by 11 feet high-water	160,000

An appropriation of $50,000 was recommended for the commencement of work on channel No. 4. It was also stated that—

After the construction of channel No. 4, and after it shall have reached a condition of permanency in its amended cross-sections, it will be time enough to decide whether it shall be widened without deepening, or deepened without widening, or whether it shall be both widened and deepened.

The question in its practical results would probably resolve itself into a channel about 100 feet wide and 13 feet deep at ordinary high-water, as the one of the greatest self-maintaining capacity.

The object of this improvement was to make Fernandina Harbor the sea-port for Saint John's River, and thus avoid the shallow, dangerous, and constantly-shifting bar which obstructs the mouth of that stream. No similar argument is applicable to the inside passage between Fernandina and Brunswick, and a channel that will accommodate, without much detention, a small class of vessels drawing from 6 to 8 feet of water will suffice, at least for the present.

An appropriation of $10,000 is recommended to be applied in dredging the channel to a minimum low-water depth of 6 feet. Its degree of permanency, when once established, will determine whether further appropriations can be judiciously made for its maintenance or enlargement.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Col. of Engineers, Brt. Maj. Gen, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

H 8.

BRUNSWICK HARBOR, GEORGIA.

UNITED STATES ENGINEER OFFICE,
New York, April 29, 1876.

GENERAL: I have the honor to acknowledge the receipt of a letter from the Office of the Chief of Engineers, dated 20th instant, referring

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to me, for report, the following resolution of the Senate of the United States:

IN THE SENATE OF THE UNITED STATES,
April 18, 1876.

Resolved, That the Secretary of War be, and he is hereby, directed to communicate to the Senate all information now in possession of the Department, or of the engineer in charge of the district of Georgia, relating to the importance of the harbor of Brunswick, Ga., and of the necessity for the improvement of said harbor.

Attest:

GEO. C. GORHAM,
Secretary.

I am in doubt whether the information in my possession will enable me to prepare a report possessing that exhaustive character which the phraseology of the resolution would seem to require. It may, however, be sufficient to meet the objects of the inquiry.

The harbor of Brunswick is situated upon the coast of Georgia, a little to the northward of the thirty-first parallel of latitude. The main channel of entrance from the ocean lies between Saint Simon's and Jekyl Islands, which are a trifle over 1 mile distant from each other.

Over the bar which obstructs this entrance, and which is caused and maintained by the combined action of the tidal currents and waves, and not by the deposit of sediment brought down from the interior, there is a permanent channel, about 17 feet deep at mean low-water, with a mean rise and fall of 6.8 feet, and a rise and fall at spring-tides of 8.2 feet. The anchorage-ground inside is of great capacity, with low-water depths largely in excess of what would be required for the largest vessels ever yet constructed.

In the channel-way between the two islands already named, the low-water soundings, for a distance of nearly 2 statute miles, exceed 7 fathoms, and above this 5 fathoms can be carried for an additional stretch of 2½ miles. Three and a half fathoms are then encountered for a distance of 200 to 300 yards, when the depths again increase to 4 fathoms, which can be carried up to a point abreast the lower end of Blythe Island, a distance of 14 miles from the bar, measured along the channel.

Above the lower point of Blythe Island, for a length of 4 miles, there is a low-water channel of 19½ feet depth, while 18 feet can be carried up an additional mile to near the head of the island. The largest vessels that can cross the bar on the high-water of spring-tides can, therefore, ascend to the head of Blythe Island, and, with the exception of a few localities, they can lie at anchor in the main channel without grounding at any stage of the tide.

Indeed, the anchorage-grounds in respect to their depth, their capacity, and their degree of protection from the effects of storms, are unexceptionable, possessing superior advantages to those of any harbor upon our coast south of Hampton Roads, with the possible exception of Port Royal and its tributary, Broad River. There is, however, 1.7 feet more water upon the Port Royal than upon the Brunswick Bar.

As compared with other harbors upon our southern coast, the volume of land-drainage into Brunswick Harbor is small, there being no long fresh-water streams emptying into it. It is, indeed, an arm of the sea, in which the waters of the ocean ebb and flow. The climate is exceptionally healthy and salubrious, being in great measure free from that class of diseases which generally prevail near the mouths of large rivers, where the river and sea water meet. Its mean temperature is about 67° Fahrenheit, while the thermometer seldom rises above 94° or falls below 31°.

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In compliance with a resolution of the United States Senate appointing commissioners "to survey and examine ports south of the Chesapeake, with a view to their comparative facilities and advantages for the establishment of a navy-yard," Commodores Wolsey, Claxton, and Shubrick, the commissioners under the above resolution, under date of December 20, 1836, made a report upon the harbors of Charleston, S. C., Beaufort, S. C., and Savannah, Darien, Brunswick, and Saint Mary's, (Fernandina,) Ga. The commissioners give a brief summary of their opinions in the following language:

The undersigned, in obedience to a resolution of the Senate, have arrived at a point where they are directed to report on "the comparative advantages and facilities of ports south of the Chesapeake for the establishment of a navy-yard." Depth of water and easy access being objects of the first consideration, they are of opinion that the ports of Charleston, Darien, and Saint Mary's, (Fernandina,) being deficient in depth of water to permit the entrance of a larger ship than a sloop of war, are unfit to compete with the frigate-harbors of Beaufort, Savannah, and Brunswick. The preference is narrowed down to one of these; and, having duly weighed their relative pretensions, we have no hesitation in preferring Brunswick. Beaufort must yield to her in the essential points of depth of water, easy access, and capability of defense. Savannah must give way, for her easier access and greater depth of water on the bar cannot be carried up the river to a site safe from the sea and an enemy, and applicable to the establishment of a navy-yard.

If a frigate could but reach Cockspur Island, the opinion expressed in favor of Brunswick might be recalled.

Brunswick is the most southern frigate-harbor on the Atlantic seaboard. Placed near the great outlet of the commerce of the West Indies and Gulf of Mexico, her position in a state of maritime warfare would be invaluable, since the navigating-interests of an enemy must pass by her door.

Subsequently to the date of this report, in 1855 I think, Congress made an appropriation for the establishment of a naval depot in Brunswick Harbor, and a portion of the Blythe Island (1,400 acres) was purchased for that purpose. From the great depths of water along the shore of this island, and the well-known healthfulness of the locality, the site would seem to be an eligible one. It is now covered with live-oak and yellow pine.

Brunswick is the terminus of two completed lines of railroad, one leading northwest to Macon and Atlanta, with good connections to the north and west; the other leading west across the State of Georgia, and connecting with the roads in Alabama to the west.

It is the natural shipping-port for the proposed water-communication between the Mississippi River and the Atlantic seaboard by way of the Tennessee and the Altamaha Rivers, and was adopted as such in the reports and estimates made by Major McFarland, Corps of Engineers, who states that the distance from Saint Louis to Brunswick by that route is 1,508 miles by careful measurement. Major McFarland also says:

The distance from Saint Louis to New York by way of the Illinois and Michigan and Erie Canals is 1,960 miles; and by way of the Portsmouth, Ohio, and Erie Canals it is 1,813 miles. These two distances are taken from the "Report of the committee of the National Board of Trade on a continuous water-line of transportation through Virginia," printed at Richmond, Va., in 1869.

The difference of distance in favor of the Brunswick route to a port is 305 miles, about one-sixth of the whole distance to New York, and as the saving in distance is entirely by river, over which the actual cost of transporting freight is about 3 mills per ton per mile, the saving of cost from this cause alone equals 91½ cents per ton.

Three transfers of cargo are saved, which amounts to 30 cents a ton more, and as the Ohio route includes about 300 miles more of canal than the Brunswick route, over which the difference of cost of transportation is not less than 2 mills per ton per mile, 60 cents, the total saving in cost by the Brunswick route is $1.81½ per ton, or about 5½ cents per bushel.

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The town of Brunswick is situated about 8 miles above the narrows formed by Saint Simon's and Jekyl Islands, upon a branch of the main stream which flows around Buzzard's Island. In this branch, near its lower confluence with the main channel, and below the town, there is a shoal upon which there is only 10 feet soundings at mean low-water, which ought to be removed. This could probably be accomplished by constructing a jetty from the most easterly point of Buzzard's Island, so located as to narrow the water-way to about 1,000 feet. Its direction should be parallel to the low-water line of the opposite shore of the branch, and its crest should not be placed higher than the level of ordinary low-water, in order that the entrance of the flood may be obstructed as little as possible.

ESTIMATED COST OF JETTY.

A jetty, located as shown on sketch, running out to the 18-foot curve, will have a length of about 3,400 feet. Applying to its construction the gabion system as practiced at Galveston, Tex., about 1,600 feet of its length will require but a single tier of gabions, 1,500 feet a double tier, and 300 feet a triple tier, provided that the crest of the jetty is made about level with the low-water line. In estimating the cost, it is assumed that in either tier only a single row of gabions is required, expecting that by the time a second tier is necessary on top of a bottom tier enough sand will have accumulated in rear of the latter to do away with the necessity of a double row of gabions at the bottom. To prevent under-washing, a number of short spur or wing jetties in single tiers may be necessary, the aggregate length of which is reckoned at 1,800 feet.

At Galveston, the cost of one linear foot of single-tier gabions, in place, was found to be $5.42. For the jetty under consideration it will be safer to raise the price to $6, and to put the contingencies at 30 per cent. The cost will then be as follows:

1,600 linear feet gabion-jetty, single tier, at $6	$9,600
1,500 linear feet gabion-jetty, double tier, at $12	18,000
300 linear feet gabion-jetty, triple tier, at $18	5,400
1,800 linear feet, spur-jetty, single tier, at $6	10,800
Add 30 per cent. for contingencies	13,200
Total	57,000

ESTIMATED COST OF DREDGING, THE JETTY BEING OMITTED.

If a channel be cut through the 10-foot shoal 100 feet wide at bottom and 15 feet deep at mean low-water, vessels drawing over 21 feet can pass through at high tide and reach the deep anchorage near the city. At 25 cents per cubic yard of dredging, the cost will be—

For 50,000 cubic yards, at 25 cents per yard	$12,500
Add 20 per cent. for contingencies	2,500
Annual dredging, 15 per cent. of the above, capitalized at the rate of 5 per cent.	37,500
Total	52,500

It cannot be determined, from the information in my possession with regard to the materials composing the shoal and the existing velocity of the ebb-current, whether the increased scour produced by the jetty would be sufficient to remove the shoal without recourse to dredging. No dredging is included in the foregoing estimate for a jetty.

An appropriation of $25,000 is recommended for this work.

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Statistics of the commerce of the port of Brunswick from 1870 to 1774, inclusive, are appended, marked "A."

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Col. of Engineers, Brt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX A.

Statistics of foreign and coastwise trade of port of Brunswick, Ga., for the years 1870 to 1874, inclusive.

Year.	ENTERED.		CLEARED.		Value of imports.	Duties.	Value of domestic exports.
	Foreign.		Coastwise.				
	Number of vessels.	Tonnage.	Number of vessels.	Tonnage.			
1870	45	25,200	80	19,000	$217,000	$112,000	$232,000
1871	12	13,200	146	44,000	186,500	86,000	398,000
1872	21	20,000	228	61,400	5,600	1,219	480,000
1873	39	18,900	286	77,400	11,200	2,240	571,000
1874	50	21,500	304	77,800	6,000	800	691,000

APPENDIX I.

ANNUAL REPORT OF CAPTAIN A. N. DAMRELL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., July 14, 1876.

GENERAL: I have the honor of transmitting herewith annual reports of operations, with financial statements, for the year 1875-'76, for the river and harbor improvements under my charge.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

I 1.

IMPROVING HARBOR AT MOBILE, ALABAMA.

This improvement was continued during the past fiscal year in accordance with the original plans and instructions furnished by a special Board of Engineers, approved by the Chief of Engineers, modified by authority from the Chief of Engineers by letter dated April 25, 1875, in regard to the widening of Choctaw Pass Channel from 200 feet to 300 feet.

The work in the channel through Dog River Bar was carried on under

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an unexpired contract with Mr. J. P. Stewart, and an unexpended balance of an appropriation of $100,000 made by act of Congress approved June 23, 1874. During the month of February, 1876, this channel was completed to its full width of 200 feet, with a depth of 13 feet at mean low tide, and operations on this bar were suspended.

The amount of material removed from this channel during the year is as follows:

	Cubic yards.
Month of July, 1875	20,818
Month of August, 1875	22,761
Month of September, 1875	14,524
Month of October, 1875	14,878
Month of November, 1875	24,105
Month of December, 1875	6,689
Month of January, 1876	25,345
Month of February, 1876	5,573
Making a total for the year of	134,693
Total previously excavated	912,889
Giving the amount of	1,047,582

removed by the United States Engineer Department from Dog River Bar Channel.

Up to this date this channel has remained unchanged; the time since its completion, however, has been very short, and at present no reliable opinion can be formed as to its permanency. From observations made so far, it is reasonable to assume that for a number of years no dredging will be required in this channel.

As stated in my last annual report, an appropriation of $26,000 was made by act of Congress approved March 3, 1875, and the project of applying this appropriation to the widening of Choctaw Pass Channel from 200 feet to 300 feet was approved by the Chief of Engineers, by letter dated April 28, 1875. Under authority from the Secretary of War dated May 3, 1875, advertisements for proposals for this work were published, dated May 7, 1875. On June 26, 1875, five bids were received and forwarded; and by letter from the Chief of Engineers dated July 20, 1875, the contract was awarded to Mr. S. N. Kimball, he being the lowest responsible bidder, at 17 cents per cubic yard. By the terms of this contract dredging was to be commenced on or before November 30, 1875, and the contract completed June 15, 1876.

Apparently, ample time was specified in the contract for completing the work, had not the rise in the river and consequent increased lateral current at Choctaw Pass compelled me to repeatedly suspend the work, to prevent the channel previously dug from being filled up by the sand stirred up by the working of the dredge.

Mr. S. N. Kimball, the contractor, being aware that under the circumstances he would not be able to complete his contract by the time specified, made application for an extension of his contract until September 15, 1876.

This letter, with my recommendation, being forwarded to the Chief of Engineers April 13, 1876, the application was approved, and the time for the completion of his contract was extended to September 15, 1876, by letter from the Chief of Engineers dated April 19, 1876. Since April work has been steadily carried on, and it is now expected that the widening of Choctaw Pass Channel to 300 feet will be completed in August, 1876. Eighty-five thousand eight hundred and eighty-two cubic yards of material were excavated from this channel during the year. During last winter's freshets a number of sunken logs were deposited in the channel; and, before they could be removed, caused some filling in near

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its northern end, considerably increasing the amount of material to be removed. The estimate for the completion of this improvement is—

40,000 cubic yards dredging, at 17 cents	$6,801
Due on contract	1,459
Engineering and office expenses	1,500
	9,760

The funds available July 1, 1876, are deemed sufficient for the completion of the improvement, and no appropriation is asked for.

Mobile Harbor is situated in the collection-district of Mobile, and Mobile is the port of entry.

The following statement of the commerce of this port has been furnished me by the collector:

The number of vessels entered during the year is 232, with a tonnage of 118,917; number cleared is 231, with a tonnage of 118,740. The total value of exports of domestic produce is $15,156,224; value of imports, $1,611,020.

Money statement.

Amount available July 1, 1875	$71,437 39
Amount expended during fiscal year ending June 30, 1876	55,171 56
Amount available July 1, 1876	16,265 83

I 2.

IMPROVING HARBOR OF CEDAR KEYS, FLORIDA.

The survey of this harbor was made in 1872, and by act of Congress approved June 10, 1872, $7,500 were appropriated to commence the improvement.

Proposals for dredging under this appropriation were advertised for, and by letter from the Chief of Engineers, dated September 12, 1874, the contract was awarded to Mr. James E. Slaughter, at 99 cents per cubic yard. Dredging was commenced in May, 1875, and continued until June 11, 1875, when the appropriation was exhausted after excavating 6,691 cubic yards of material from a cut 60 feet wide, 1,350 feet long, and 12 feet deep at mean low tide, commencing at the 12-foot curve outside the bar and extending to within 200 feet of the bar-buoy.

By act of Congress approved March 3, 1875, an appropriation of $1,500 was made to continue the improvement of this harbor. The project of expending this appropriation in completing the dredging of a channel 100 feet wide and 12 feet deep at mean low tide, through the outer bar, having been approved by the Chief of Engineers, proposals for bids were published, and 4 bids received and forwarded to the Chief of Engineers June 26, 1875. (See Report for 1875, vol. 2, page 8.)

By letter from the Chief of Engineers dated July 20, 1875, the contract was awarded to Mr. James E. Slaughter, at 59½ cents per cubic yard. On July 26 the contract was signed and executed by him, and on August 11, 1875, dredging was resumed and continued until the 3d of December, 1875, when the cut through the outer bar 100 feet wide from the 12-foot curve outside to the 12-foot curve inside was completed, and the appropriation being exhausted, work was suspended.

The amount of material excavated under this contract is as follows:

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	Cubic yards.
August, 1875	4,265
September, 1875	4,234
October, 1875	8,201
November, 1875	6,251
December, 1875	1,094
Making a total for the year	24,045
Amount excavated previously	6,691
Giving a total of	30,736

cubic yards excavated from the channel through the outer bar.

From late information received, this channel has retained its original depth of 12 feet at mean low tide; it is, however, too narrow to answer the requirements of the commerce of the port, and should the appropriation asked for be made by Congress, it is proposed to apply the same—

1st. To the widening of the channel through the outer bar to the width of 200 feet.

2d. To widening and deepening the channel inside Sea-Horse Key.

3d. To widening and deepening the channel at the bend between Depot Key and Harbor or Grassy Key.

Original estimated cost of work	$133,500
Whole amount appropriated for this project	22,500
Appropriation asked for fiscal year ending June 30, 1878	50,000

Money statement.

Amount available July 1, 1875	$15,343 62
Amount expended during fiscal year ending June 30, 1876	15,338 67
Amount available July 1, 1876	4 95
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	101,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

I 3.

IMPROVEMENT OF CHOCTAWHATCHEE RIVER, ALABAMA AND FLORIDA.

At the beginning of this fiscal year the work of improving this river was carried on under an unexpended balance of the appropriation of $5,000 made by act of Congress approved March 3, 1875, and was continued until September 15, 1875, when, for want of further funds, operations had to be suspended. The work was mainly confined to the removal of snags, stumps, and overhanging trees, a large number of which were pulled, cut, and removed from the river. A channel about 3 feet deep at low-water has been attained from the mouth of the river to Buzzard Bar, about 15 miles below Geneva, at which point the work had to be suspended.

A wagon-road around this bar was, however, previously cut through the woods to facilitate the transfer of freight at that point. The improvement of Buzzard Bar, the dredging of loose rock and gravel from some of the upper shoals and bars, the removal of some steamboat-wrecks, and the snagging and clearing of 15 miles of the river still remain to be done before light-draught boats can ascend to Geneva during low-water. It is proposed to resume work on this river as soon as an appropriation is made by Congress.

Original estimated cost of this work as now being carried on	$34,332
Whole amount appropriated since the adoption of the present project	10,000
An appropriation is asked for the fiscal year ending June 30, 1878, of	25,000

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Money statement.

Amount available July 1, 1875	$3,297 30
Amount expended during the fiscal year ending June 30, 1876	3,012 37
Amount available July 1, 1876	284 93
Amount appropriated by act approved August 14, 1876	5,000 00
Amount (estimated) required for completion of existing project	19,332 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	20,000 00

I 4.

IMPROVEMENT OF APALACHICOLA RIVER, FLORIDA.

An appropriation of $10,000 for the improvement of this river was made by act of Congress approved June 23, 1874.

At the close of the previous fiscal year the snag-boat Clara Dunning was engaged on the improvement of Mocassin Slough, which had been partly accomplished during that year, and after continuing the work through the months of July and August, 1875, during which time 108 snags and sunken logs were pulled out, over 100 overhanging trees cut and removed, and 1,831 cubic yards of earth excavated to straighten the channel at the junction of the river with the slough, the snag-boat was moved on the Chattahoochee River, and work on the Apalachicola suspended, a navigable channel for boats drawing 5 feet having been attained from its mouth to the junction of Chattahoochee and Flint rivers.

During the last freshet a large raft of logs lodged near the junction of Mocassin Slough and Styx River, seriously obstructing navigation. In the month of June, 1876, this raft was removed, and at the close of this year the river is again in fair navigable condition. A considerable amount of work, however, remains to be done in straightening the channel through Mocassin Slough and Styx River to prevent the lodging of rafts and logs in future in the short bends still existing.

It is contemplated to continue the improvement of this river during next year by straightening its channel through Mocassin Slough and Styx River.

The unexpended balance of former appropriations, with the amount asked for next fiscal year, is deemed sufficient to complete the work, and no appropriation is asked for fiscal year ending June 30, 1878.

Appropriation asked for fiscal year ending June 30, 1877	$10,000
Original estimated cost of the work as being now carried on	80,000
The whole amount appropriated since the adoption of the present project	20,000

Money statement.

Amount available July 1, 1875	$13,225 61
Amount expended during fiscal year ending June 30, 1876	4,670 11
Amount available July 1, 1876	8,550 50
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	10,000 00

I 5.

IMPROVEMENT OF CHATTAHOOCHEE AND FLINT RIVERS, GEORGIA.

By act of Congress approved March 3, 1875, $25,000 were appropriated for the improvement of these rivers, making the amount available for the continuation of the work during the year $36,582.62.

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CHATTAHOOCHEE RIVER.

As stated in my last annual report, work on this river had to be suspended as early as December, 1874, on account of a high freshet, and could not be resumed until the latter part of August, 1875. During the freshet a few land-slides occurred, interfering seriously with navigation, and, as soon as the stage of the water permitted, snags and trees carried in the channel by these slides were removed, and the improvement of Wolfox Bar, commenced during the previous year, was resumed.

A careful examination of this bar, after the freshets, evinced the facts that the jetty constructed during the previous year had in some measure produced the desired effect of deepening the channel; it had, however, created a considerable abrasion of the opposite shore, (Georgia side,) and a tendency to form a new shoal below the bar was also observed.

To prevent these injurious effects and make this improvement permanent, 380 feet of breakwater were constructed along the Georgia shore to prevent further washing, and a jetty 200 feet long was thrown out below this to prevent the formation of a new shoal at that point. The jetty above the bar, on Alabama side of the river, was then extended 235 feet inshore to high-water mark to prevent the river from washing behind it during freshets. Before the completion of the latter work (some filling-in with rock and gravel remaining to be done) a sudden rise in the river compelled a suspension of further operations during the season.

This freshet continued until May, 1876, during which month the water fell sufficiently to justify the resumption of work on this improvement. Necessary repairs to the snag-boat were at once made, and to the close of the year this boat was employed in removing trees and snags left in the channel by the receding waters.

It is proposed to confine operations on this river to the improvement of bars and shoals between Eufaula, Ala., and Columbus, Ga., during the fiscal year.

FLINT RIVER.

All snags, logs, and overhanging trees interfering with navigation on this river from its mouth to Bainbridge, Ga., were removed by the snag-boat during the year. It becoming evident that it was impossible to prosecute the work on the many rocky bars and shoals in this river with the snag-boat during the low stage of the water, two light-draught flat-boats have been constructed for the accommodation of the working-party, which will be fitted out with necessary blasting and hoisting apparatus.

It is proposed to prosecute the improvement in this river, by blasting and removing rocks from the channel over the bars and shoals, from its mouth to Bainbridge, Ga., during the next fiscal year.

Appropriation asked for for fiscal year ending June 30, 1878	$50,000
Original estimated cost of the work as now being carried on	330,000
Whole amount appropriated since the adoption of the present project	50,000

Money statement.

Amount available July 1, 1875	$36,582 62
Amount expended during fiscal year ending June 30, 1876	8,979 56
Amount available July 1, 1876	27,603 06
Amount appropriated by act approved August 14, 1876	20,000 00
Amount (estimated) required for completion of existing project	260,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	50,000 00

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I 6.

IMPROVEMENT OF BLACK WARRIOR AND TOMBIGBEE RIVERS, ALABAMA.

Under an appropriation of $25,000 made by act of Congress approved March 3, 1875, and in accordance with the project submitted by me for the prosecution of this improvement of these rivers, and approved by the Chief of Engineers, the work was commenced during July, 1875.

On account of the difficulty encountered in obtaining necessary materials, the construction of the boats required for the prosecution of the work was considerably delayed. A small force was, however, employed at Tuscaloosa Landing blasting and removing rocks and constructing dams for the removal of some sand-bars above and below the landing. In the middle of August the first flat-boat and tender were completed, and work at Eagle Bar, below Tuscaloosa, was commenced. Three more flat-boats, with tenders, were built successively, and put on the work as fast as they could be equipped and manned, and by October 4 a full force of 100 men were employed. Three of these boats, with their tenders, were engaged on the bars and shoals in constructing the works required for their improvement, while the fourth, which had been fitted up as a snag-boat, was pushing its way down the river, removing snags, sunken logs, and overhanging trees as it advanced.

During the months of September and October, sickness prevailed to such extent among the men that one-fourth to one-third of them were constantly on the sick-list, and in November, when the whole force was in good working-condition, winter rains began to set in, and by the 26th of that month the river had risen to such a height that work had to be suspended, the men discharged, and the boats laid up in a safe place for the winter, thus reducing the season's work (which is generally estimated at six) to less than three months' full work.

On rivers like the Black Warrior and Tombigbee, whose bottom and shores are principally formed of materials easily moved by the current, shoals and bars are usually found where the river, by the washing of its shores, has attained an unusual width, or in some instances where an accumulation of sunken logs interferes with the free flow of the water.

The general plan adopted in this improvement was, 1st, the removal of all snags and sunken logs; 2d, the construction of jetties and parallels to contract the width of the river, and, 3d, in protecting the shores, where necessary to prevent futher abrasion. The removal of snags and sunken logs was accomplished by the snag-boat, which, however, has proved too light for the heavy strains to which she had to be subjected, and a stronger boat is being built for next season's work. Jetties and other works were constructed with the forces on the three other boats and their tenders, which latter were supplied with small pile-drivers.

The method selected for building jetties and parallels was to drive piles 4 feet apart, in two rows, with 3 feet space between them; to fill in this space with closely-packed brush to 4 to 6 feet above low-water; to cap the piles crosswise to keep them from spreading; to cover the whole structure with earth and gravel, which were allowed to form their own slopes on either side. The earth penetrated and filled the interstices between the brush, so that the jetties acquired great strength in resisting the action of the water. During last winter's heavy freshet they not only remained intact, but were strengthened by large accumulations of sand and gravel, and have in most instances already produced the desired effect of deepening the channel. Where the action of the jetties had a tendency to undermine the opposite shore, a single row of

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piles was driven parallel with that shore and well wattled with cane; this simple structure has been found to fulfill its purpose admirably.

As soon as the river has fallen to low-water mark, a careful examination of the condition of the works and their effect on the regimen of the river will be made, to serve as a guide in planning future improvements on these rivers.

During the month of June, 1876, all the boats engaged on this improvement have been put in thorough repair; a new snag-boat has been built; and should the river, as is expected, reach its low-water stage, a full force, with all necessary outfit, will begin operations during the latter part of this month, or by July 1, 1876.

I append herewith a summary of amount and kind of work done on the different bars and shoals during the past fiscal year:

Name of bar.	Jetties.	Shore-lining.	Dams.	Rock.	Gravel.	Snags.
	Feet.	*Feet.*	*Feet.*	*Yards.*	*Yards.*	*Number.*
Tuscaloosa Landing	250	.....	.....	350	600	2
Eagle Bar	318	.....	.....	.....	710	8
Little Log Shoals	91	.....	108	.....	.....	25
Tressel's Bar	638	.....	180	.....	3,000	5
King's Mountain Bar	125	.....	140	.....	75	107
Cunningham's Bar	355	.....	.....	.....	.....	.....
Collier Foster's Shoal	.....	.....	.....	.....	.....	19
Bald Bar	110	450	95	.....	210	93
Big Sandy Bar	150	.....	170	.....	.....	48
Vancleve's Shoal	113	.....	.....	.....	.....	9
McCown's Bar	513	.....	.....	.....	.....	16
Mud Bar	60	135	.....	.....	37	4
Wild Horse	198	.....	.....	.....	.....	5
Beale's Bar and Reef	250	.....	.....	11	.....	2
Buzzard Bar	378	.....	275	.....	76	31
Gray's Bar	100	.....	.....	.....	.....	17
Eddin's Reef	225	.....	260	.....	.....	21
Lily Wreck Bar	70	.....	.....	.....	.....	.....
Izzard Shoal	175	206	.....	.....	.....	.....
Mike's Bar	232	.....	.....	.....	.....	3
Drop Out Bar	182	.....	.....	.....	.....	.....
Total	4,533	791	1,228	361	4,708	417

In regard to the statistics of the trade on these rivers, I am only able to give the number of bales of cotton shipped to Mobile since September 15, 1875: Black Warrior, 30,560; and Tombigbee, 51,786.

It is proposed to continue work on the improvement of these rivers during next fiscal year.

Original estimated cost of the work as now being carried on for Black Warrior	$151,103 00
Tombigbee River, (see report 1870–'71)	21,500 00
	172,603 00
Whole amount appropriated since the adoption of the present project	25,000 00
Amount asked for fiscal year ending June 30, 1878	100,000 00

Money statement.

Amount available July 1, 1875	$25,000 00
Amount expended during fiscal year ending June 30, 1876	19,881 92
Amount available July 1, 1876	5,118 08
Amount appropriated by act approved August 14, 1876	15,000 00
Amount (estimated) required for completion of existing project	132,603 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	100,000 00

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I 7.

EXAMINATION AND SURVEY OF THE ALABAMA RIVER, FROM WETUMPKA TO ITS MOUTH.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., March 8, 1876.

GENERAL: I have the honor to report that the examination and survey of the Alabama River, from Wetumpka to its mouth, provided for by act of Congress approved March 3, 1875, and assigned to my charge by letter from your office, has been very much delayed by high-water in the river, which prevented an early commencement of the work, and retarded its progress at various times afterward, by sickness of the parties employed, from malarious influences; and by the severe indisposition of Mr. Yuille, assistant engineer in immediate charge of the work since the completion of the field-work, brought on by his labors in connection with it.

The report and estimates, in their present condition, are forwarded now, rather than delay longer for a more perfect presentation of the subject.

The examination has resulted in showing the Alabama River to be in need of and susceptible of great improvement by a moderate expenditure.

Two estimates are submitted:

1. For obtaining a channel 200 feet wide and 4 feet deep at low-water, at a total cost of $229,741.

2. For obtaining a channel 150 feet wide and 6 feet deep at low-water, at a total cost of $459,773.25.

The first project is recommended as giving all that is needed at present, and should the future commerce on the river demand a greater depth, as is very probable, the money expended in carrying it out will be judiciously expended for executing the second project.

A great deal of difficulty has been met with in obtaining full commercial statistics, but such as can be will be forwarded as soon as they can be prepared.

Complete details will be found in the report of Mr. Yuille, accompanying this.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

P. S.—The following figures have been furnished me since, by parties connected with the commerce on this river:

Fifty-one thousand two hundred and sixty-eight bales of cotton have been received at Mobile, Ala., from the Alabama River since September 1, 1875, and the amount of up and down freight collected during the past year is $140,000.

As at the opening of the cotton season the river is usually at a low stage of water, and boats can only carry small loads, nearly one-third of the cotton-crop tributary to this river is carried by railroad to the Atlantic sea-ports, and it is to be reasonably expected that by the proposed improvement the trade of this river will increase nearly to that extent.

An appropriation of $50,000 is asked for fiscal year ending June 30, 1878.

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REPORT OF MR. GAVIN B. YUILLE, ASSISTANT ENGINEER.

MOBILE, *March* 1, 1876.

MAJOR: I have the honor to submit herewith my report on the examination and partial survey of the Alabama River from Wetumpka to its mouth.

In obedience to your letter of instruction, dated July 27, 1875, I left the city of Mobile on the same day, and proceeded by the usual route of travel to Wetumpka, arriving there on the morning of the 28th, and took immediate steps to procure a suitable flat-boat, and arrange for necessary fitting of same for the service required.

In furtherance, also, of the work in view, I was engaged some days at Montgomery in making tracings of United States township maps, embracing the Alabama River, from the records in the secretary of state's office, and in procuring other data relating to river elevations above tide-water, at points crossed by railroad surveys, obtainable from records of the railroad companies.

On the 14th of August, the river at Wetumpka indicating its near approach to the usual low-water stage, and the fitting of the boat being about completed, the necessary party for the work were engaged and organized. While engaged on some examination of the river at Wetumpka, work was intercepted by heavy rains, which, extending to the upper waters of the Coosa River, caused a rise of 9 feet, delaying the start down the river till the 25th of August, when the boat was cast loose with a rise yet in the river of 3 feet above usual low-water.

Admonished by the already rapid inroad of lost time upon the possible season of low-water at command, it was not deemed prudent to attempt any extended surveys, or even a partial instrumental survey, of all the probable points requiring investigation. Taking into consideration, also, the small means at command and the many miles of river to be examined, it was determined, as the proper plan, to secure a completed general result by a careful examination of the whole river, rather than a probable incomplete result by attempting a survey of every point offering obstruction to navigation.

In conformity to this plan, instrumental surveys were only made at those points where, from their magnitude or departure from the usual character of other obstructions, a survey seemed necessary to properly set forth the nature and character of it. In conducting this examination there was soon developed a similarity in the characteristics of many of the bars that was striking; so that a careful consideration of one secured a result applicable to many. Governed by these considerations of plan and economy of time and means, the examination was steadily pushed on to completion at the mouth of the Alabama River, on the 26th of October, interrupted, however, by sickness of party, and delays caused by the occurrence of several rises of the river.

This completing the required examination of the Alabama River, the boat was moved on down the Mobile River as rapidly as adverse winds and tides would admit, reaching Mobile on the 30th of October, when the party was discharged, the instruments and other property properly accounted for, and I reported in person at your office for further duty.

Accompanying this report are the following papers:

1. Index-map, in two sheets, Nos. 1 and 2, scale 2 inches to the mile, compiled from United States township maps, showing the entire river from Wetumpka to its mouth, with the relative position of the bars, shoals, reefs, &c., and the situation of important towns and places of trade upon and adjacent to the river, with their railroad connections.

2. Maps of surveys, in eight sheets, marked A to H inclusive, scale 200 feet to the inch, or $\frac{1}{2400}$, showing some of the more important obstructions to navigation.

The amount appropriated for the examination not justifying any extended surveys, (as heretofore stated,) every effort was made to collect whatever data was available from railroad surveys and other sources, that had a bearing upon the object to be attained, so as to arrive at just conclusions regarding the inclination of river-bed, volume of discharge at minimum stage, and oscillation in times of flood, upon which to base a correct opinion as to the proper treatment for the removal of and the remedy for the obstructions to navigation found. Having in view, first, what may be termed a restoration of the normal capacity of the river; second, to determine the possible maximum capacity of same under a more extended improvement, with the conditions of volume, inclination of river-bed, and probable character of necessary excavations, as elements of the question.

EXAMINATION AND SURVEY.

The results of the examination may be briefly stated as follows: Commencing at Wetumpka, which is situated at the head of an open reach of navigable water on the Coosa River and at the foot of the last of a series of rapids that obstruct the upper portion of that river, with a width here of 400 feet, between fixed and stable banks, partly formed of gneiss rock, through which the river has made its way, it assumes a lake-like appearance, maintaining a uniform width, with a very moderate current, and

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depth of not less than 6 feet, till the mouth of the Tallapoosa River is reached, the junction of which with the Coosa forms the Alabama River proper.

At the mouth of the Tallapoosa we come upon the first serious obstacle to navigation, caused by an extensive deposit of coarse gravel in the channel of the united rivers, brought down the former in times of flood, filling up the bed and causing a widening of the main river, with a consequent dispersion of the water into several shifting channels, through which only about 2 feet depth is found at low-water stage. The filling up of the main river, acting as a dam, has caused a great increase of the natural inclination of the river-bed below, and the formation of slack-water pools in each above the obstruction. The formation of this dam or bar in the main river is evidently the result of the very square entrance of the Tallapoosa into the Coosa, with the heavy character of deposit brought down the former and discharged into the channel of the latter, together with the very unstable nature of the adjacent river-banks, allowing an undue widening to take place with the ever-varying conditions of each river in flood and low-water.

This disturbance of the otherwise favorable condition of the river continues for about 3 miles, when the normal character of the river is again found, with an increase of width to 500 feet since the accession of the Tallapoosa, and with a depth of from 6 to 15 feet in all open reaches of the river.

We now enter upon a portion of the river that is very uniform in its characteristics, in the character of the banks, width and depth; also in the great similarity and nature of the obstructions found; this similarity continues so long as the river is bounded one side or the other by high and solid bluffs.

It is therefore unnecessary to enter into a minute description of the successive obstructions found; a general illustration of the governing characteristics will be more useful.

The banks generally of the upper portion of the river are of a solid and firm nature, and in no case was there found any extensive caving or falling in. In a very large proportion the banks upon one side of the river or the other are composed of a compact soft rock or marl, usually called rotten limestone; a material that offers an effective barrier against the eroding action of the river, and which often contain ledges of a harder material, fit in many places for building-stone; the bluffs also contain large quantities of nodules or concretions of a hard and solid character, that fall from the face of bluff and collect at the edge of low-water, that would make suitable material for filling cribs of dams and jetties, easily gathered by boat at low-water.

This general character of the river, however, is only applicable to those parts that are free from islands, bars, and shoals, of which there are great numbers, as shown upon the index-map. These obstructions may be said to have resulted from the failure in resistance offered to the action of the river by the caving of the banks, allowing an increase of width in the flood-stage, and the consequent filling by timber, gravel, and sand in the unduly-widened river-bed during the subsidence of flood. This action has in the course of time divided the channel, forming islands and bars with those in a less advanced state, constituting the present shoals.

The foregoing description of character of river applies to that portion commencing near the mouth of Tallapoosa River, and extends to a point between Claiborne and Gainstown, where the high bluffs come to an end. The width of the river in this portion ranges from 500 to 600 feet, and wherever that width is exceeded will be found the bars and shoals. In the open reaches of river ample water is always found ranging from 8 to 15 feet, and often much deeper. At none of the bars or shoals was there found any excessive current, and in the open reaches the current did not exceed ¾ or 1¼ miles per hour.

In this really beautiful portion of the river its usefulness is marred by many bars, shoals, and reefs, and collections of logs, at many of which points the low-water depth is reduced 3½, and even 2½ feet.

We now come to that part of the river between Gainstown and the mouth, where the width has increased to 600 and 800 feet, the depth ranging from 10 to 12 feet in the fair reaches, and upon the shoals as low as 3 feet was found for low-water.

From near this point, where the high bluffs terminate, the river-banks are mostly overflowed in high-water, and are more subject to erosion by the river; a much wider scope of the valley of river is overflowed, and we find a sudden falling-off of the oscillation.

One of the most damaging obstructions of the lower river is what is known as the "Cut-off," about 16 miles above the mouth of Alabama River, where the waters of the latter have of late years made an outlet through to the Tombigbee River, of such magnitude as to seriously impair the volume of water passing down the Alabama.

As the Cut-off serves no useful purpose, but, on the contrary, is likely at no distant day to so lessen the volume of the main river that its usefulness will be entirely destroyed by filling up, a result that has already taken place at the head of the Cut-off in the main channel, causing a shoal of scant 4 feet at low-water, requiring the loaded steamers, either passing up or down the river, to use the Cut-off, thus leaving the main

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river, upon which is situated all the landings, without reliable service during the season of low-water.

The river below the Cut-off to the mouth is as yet in good condition, requiring only the removal of logs and timber; ample water found from the Cut-off to the mouth.

Owing to the unfavorable condition of the river at the commencement of the examination, no estimate of the volume of discharge could be made at a point above Montgomery, which was deemed essential to a determinate solution of the problem of maximum capacity of channel practicable. A measurement was made, however, below Montgomery, or as soon as the river was found in a favorable condition; these measurements were made when the river was reported to be about 1 foot above ordinary low water; they are submitted as approximate only. The first was taken at a point just below Newport Bar, and gives 3,711 cubic feet per second, with mean velocity of 2 feet per second; the second was taken at Wood's Upper Landing, 20 miles lower down, and gave 3,734 cubic feet per second, with mean velocity of 1.57 feet per second.

To determine inclination of river-surface at low water, use was made of data from railroad-survey levels, and measurements of surface-velocities of the river at various points.

The oscillation was determined from actual note of the high water marks from reliable sources, and all are made from the well-established high water of the spring of 1874.

The following statement is therefore submitted, with confidence that it approximates the truth:

Statement of tide-water elevations, oscillations, and estimate of volume of discharge at various points on the Alabama River.

Name of locality.	Map-distance from Mobile.	Low water of river above tide-water at Mobile.	Oscillation of river during high water of 1874.	Volume of water per second, low water of 1875.	Remarks.
	Miles.	*Feet.*	*Feet.*	*Cub. ft.*	
Wetumpka	367	117.00	58.32	.....	River 400 feet wide at low water.
South and North Alabama Railroad bridge.	344	105.00	53.50	.....	
Montgomery	338	103.40	53.20	.....	
New Port Bar, (½ miles below)	310	.....	.....	3,711	Approximate only.
Wood's Upper Landing	291	.....	.....	3,734	Do.
Western Railroad bridge	264½	.....	55.00	.....	
Selma	256½	.....	53.00	.....	
Claiborne	119½	.....	42.00	.....	End of high bluffs on river.
Gainstown	95½	.....	28.00	.....	Both banks mostly overflowed during high water from this point south.
Davis's Landing	69½	.....	23.00	.....	
Cut-off	60½	12.00	21.90	.....	Oscillation and elevation estimated.
Mouth of Alabama River	44½	.....	20.00	.....	
Seymore's Bluff	31	.....	16.25	.....	
Mobile	00	0.00	1.00	.....	

From the above statement the average rate of inclination of the river from the Cut-off to Montgomery is 0.328 feet, or about 4 inches per mile; from Montgomery to Wetumpka, 0.469 feet, or 5⅝ inches per mile.

At the most rapid part of the Tallapoosa Shoal the mean velocity was determined by measurement at 4.56 feet per second, or $3\frac{1}{10}$ miles per hour, which extended about one-quarter of a mile in distance at that rate. At no other point on the river was there found such an exceptional mean velocity; therefore, without burdening this report with more data for determining the exact capacity of the river, we may safely proceed to consider plans and estimates of cost, being fully satisfied that there will be abundant volume of water to carry out any scale of improvements contemplated or the requirements of probable commerce on the river may call for.

IMPROVEMENTS.

By map-measurement the total length of river examined is 322 miles, upon which were found 116 bars, shoals, and reefs that offered more or less impediment to free navigation at ordinary low-water stage of river. In prosecuting this examination there was soon developed a remarkable similarity in the character and nature of the obstructions, determining, in the mind of the observer, a common method for their remedy. In all cases where a bar or shoal was found there was an increased width of river, and where the shoal became elevated into an island and divided the channel

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into two chutes, thus narrowing the river, one or both chutes would be found with deep water as far as the bar or island extended. At the head of the island, where the channel was yet wide, would be found the compact gravel-shoal, with shallow water; then, at the foot of the island or bar, where the river also was yet too wide, we would find the soft, shifting sand-deposit and shallow water.

The remedy in this case is evidently to confine and narrow the river, to extend the forming of the island by dam and jetty, and then narrow the channel.

Where the river has solid and secure banks, which is the case on the greater part of the river, either of one side or the other, then the channel should be thrown upon the side so secured; for it was invariably found that where the channel was so situated there was ample and deep water all along the bluff.

Some few cases were found where the channel had been thrown away from the solid bluff to the opposite side, and it rarely happens that the river has a bluff on each near enough to form channel-width. The proper course in this case would be to secure the channel against the solid bluff, even at a greater cost, from the certainty of making it secure against change in the future.

In but few cases were rocky reefs found, and these were mostly of the soft rock similar to that of the bluffs, and in detached masses. No reef of rock was found that seemed to offer any obstruction to uniform flow of the river.

In the lower part of river, below Gainstown, where the banks are of more unstable nature, the improvement of the river will require the use of means to secure the banks from washing, in order to maintain the integrity of the channel.

The entire river is much obstructed by snags and logs that are bedded in the main channel and chutes, the removal of which is, in many cases, all that is necessary at some of the bars and shoals. In other cases, the removal of the bedded logs and timber from the channel will allow the current to act on the sand, and thus deepen the channel all that is necessary.

The impossibility of any enumeration of the logs, snags, and timber necessary to be removed, renders any absolute estimate of this item impossible. All that is offered as an estimate is a statement of number of logs distributed among the points requiring improvement in a ratio that is judged fair and in keeping with the observed evidences of such obstructions in that portion of the river.

ESTIMATE OF COST.

In regard to plan of structures necessary in the proposed improvement, the details must necessarily be determined for each case by the engineer when the work is to be executed; but the use of crib-dams and jetties are here estimated for upon the upper portion of the river, to be filled with gravel and protected by coverings of heavy masses of stone, and at the exposed ends of jetties and exposed points along banks to use brush and stone protection.

For the lower river piling will be more suitable, using piling also for bank-protection, with brush and stone.

Timber of good quality can be obtained at all points on the river; also suitable stone for the purpose from the river-bluffs at all points from Wetumpka to Gainstown.

The prices used in this estimate are as follows:

For the removal of logs and snags, $10 each.

For square timber of oak or pine, $20 per thousand, board-measure.

Gravel excavation and filling, each, 50 cents per cubic yard.

Soft rock or marl excavation, 75 cents per cubic yard.

Solid-rock excavation, $2 per cubic yard.

Brush and stone protection, $2.50 per cubic yard.

In submitting estimate of cost two grades of improvement are proposed: the first for a channel of 4 feet depth and 200 feet minimum width; the second of 6 feet depth and 150 feet minimum width.

The first plan contemplates such depth as may be easily secured, and at the same time the work may be made to lead in the direction of a more thorough improvement in the future.

The second plan contemplates a work of improvement that will at once secure an approximation to the full capacity of the river at low-water stage.

The 4-foot channel, it is believed, will serve the present requirements of the class of steamboats used on the river, and the execution of this work would be the first step toward a more perfect work, looking to the future development of the full capacity of river, when the increased commerce and growth of new interests shall require it.

As river-improvements of this character are always in a measure experimental, there is every reason to believe that in a case like this the full result may be obtained in some places in the effort to secure only the partial; I therefore think it but the exercise of proper prudence to recommend the application of means under the first grade of improvement.

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List of bars, shoals, reefs, and other obstructions to navigation upon the Alabama River, from Wetumpka to its mouth, with estimated cost of improvement, under two projects, one for a channel of 4 feet depth and 200 feet minimum width, and the other of 6 feet depth and 150 feet minimum width.

Map-distance from Mobile.	Name of locality.	Channel 4 feet by 200 feet.							Channel 6 feet by 150 feet.							Remarks.
		Logs to remove.	Gravel and sand excavation.	Soft-rock excavation.	Solid-rock excavation.	Brush and stone protection.	Jetties and dams.	Cost.	Logs to remove.	Gravel and sand excavation.	Soft-rock excavation.	Solid-rock excavation.	Brush and stone protection.	Jetties and dams.	Cost.	
Miles.		*No.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Lin. ft.*	*Dollars.*	*No.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Lin. ft.*	*Dollars.*	
367	Wetumpka Landing	15	100		50			550	15	500		200			1,000	Includes removal of wreck.
356	Tallapoosa Bar	10	6,000			700	600	10,550	10	12,000			1,500	900	18,400	Map-sheet A.
355	Big Bend	5		200	50	150	700	7,325	5		400	100	300	900	9,850	
354	Glenn's Chute			500	50			475			1,000	100			950	
352½	Coosada Bend	20						200							200	
351	Coosada Island												100	200	2,150	
349½	Gun Chute	15						150	15				300	200	2,800	
348½	Rock Shoals	5	500		100	100	200	2,650	5	1,500		200	200	400	5,500	Includes shoal at Point Bar just below.
346	Bend below Jackson's Ferry	3		100	50			205	3		300	100			455	
344½	Lunigton Bar	4	400					240	4	800			100	200	2,590	
339½	Montgomery Island	10						100	10				100	200	2,250	
338	Montgomery City				150			300				200			400	
336	The Three Chutes	15	500			300	400	4,950	15	2,000			400	600	7,850	
335	Gause's Upper Bar	20				50	250	2,700	20	500			200	300	3,800	
334	Gause's Lower Bar	25	800					650	25	3,000	400	100	500	300	6,350	
331½	The Rocks				100			200				200	100	200	2,550	
330½	Duncan's Bar	3				100	300	3,130	3	600			300	500	5,830	
326½	Cox's Bar	5	4,000			300	400	6,600	5	6,000			400	450	8,325	
325	Washington Bar	3	500	100	50			405	3	2,000	300	100	50	200	3,480	
324	Hadnott's Bar		500			50	200	2,275		2,000			100	300	4,100	
323	Catoma Creek Bar	10				50	200	2,125	10	3,000			150	300	4,825	
319½	Mawack's Island	15				50	400	4,075	15	600			50	400	4,375	Map-sheet B.
319	Bar below Mawack's Island	5						50	5				50	100	1,125	
317	Tallawassee Creek	10						100	10						100	
316½	Tallawassee Bar	5	1,000			100	300	3,650	5	2,000			300	400	5,600	
311	New Port Bar	10			100			300	10			300			700	
310	Tight Eye No. 2	4	500			50	100	1,365	4	1,500			100	150	2,465	
308	Mum's Landing Bar	10	500					350	10	1,000					600	
306½	Swift Creek Bar	5						50	5						50	
305½	Golson's Bar	8						80	8				50	200	2,105	
304½	Dutch Island	5						50	5				50	200	2,075	

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List of bars, shoals, reefs, and other obstructions to navigation upon the Alabama River, &c.—Continued.

Map-distance from Mobile.	Name of locality.	Channel 4 feet by 200 feet.							Channel 6 feet by 150 feet.							Remarks.
		Logs to remove.	Gravel and sand excavation.	Soft-rock excavation.	Solid-rock excavation.	Brush and stone protection.	Jetties and dams.	Cost.	Logs to remove.	Gravel and sand excavation.	Soft-rock excavation.	Solid-rock excavation.	Brush and stone protection.	Jetties and dams.	Cost.	
Miles.		*No.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Lin. ft.*	*Dollars.*	*No.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Lin. ft.*	*Dollars.*	
302	Cypress Creek Bar	3						30	3				50	200	2,055	
301	Indian's Holy Ground	15			50	50	200	2,275	15	600		100	100	250	3,275	
298	Edward's Bar	15		200		50	200	2,325	15		400		100	300	3,550	
295	Edward's Shoal	5				50	200	2,075	5				100	300	3,150	
293	Tyus Bar	3	1,000			100	200	2,680	3	3,000			100	300	4,630	
286	Bar above Benton	15						150	15				50	150	1,700	
285	Big Swamp Creek	20						200	20						200	
284½	Benton's Landing	8						80	8						80	
283½	Bar below Benton	5						50	5				100	200	2,200	
281½	Wood's Lower Landing Bar	15						150	15						150	
280	Morgan's Landing Bar	6	300			50	150	1,760	6	700			100	250	3,035	
279½	Hooper's Bar	25						250	25				100	150	1,925	
278	Upper Brother	25			50	100	400	4,400	25	1,000		50	150	500	5,975	Map-sheet C.
277½	Lower Brother	20				50	300	3,175	20	500			100	300	3,550	
275½	Creek Shoals	5		500	50	50	200	2,550	5		1,000	100	150	400	5,175	
274½	Gaston's Bar	3		400				330	3		700	50	100	300	3,755	
274	Old H—1 Bar	10						100	10				50	200	2,125	
272½	Gardner's Island	40				200	600	7,000	40		1,000		300	800	9,900	Includes removal of wrecks. Map-sheet D.
268½	Mrs. But. Smith's Landing	5						50	5			50			150	
266	Fish-Trap Bar	10			20	50	200	2,165	10			50	100	300	3,300	
260½	Kornegay's Landing, (above.)	5						50	5						50	
259½	Kornegay's Landing Bar	5						50	5				50	200	2,075	
258½	2d bar above Selma	3			30			30	3				50	200	2,055	
257½	1st bar above Selma	5						110	5			50	100	250	2,775	
256½	1st bar below Selma												50	200	2,025	
255	Valley Creek	30						300	30				50	200	2,325	
254½	Tight Eye No. 1	5	500					300	5	1,500					800	
251½	Cade's Bar	15						150	15				100	150	1,825	
248½	King's Bend Bar	20						200	20				50	100	1,275	
247½	Blackwell's Bar	25						250	25				100	200	2,400	
243	Watt's Bar	20						200	20				100	200	2,350	

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240	Cahaba Landing	10						100	10							100	
236	King's Bar	5				50	100	1,125	5				100	150	1,725		
235	Turkey Ford	15				50	150	1,700	15	500	100		100	250	3,070		
232½	Mitchell's Bar	20						300	20				100	150	1,975	Includes removal of coal-barge wreck.	
232	Mary Taylor's Bar	5	6,000			200	600	9,250	5	12,000			300	800	14,400	Map-sheet E.	
230½	White's Bar	20				100	200	2,350	20				150	250	2,950		
227½	Rifleman's Bar	5				100	150	1,725	5				100	200	2,200		
225	Upper Sister	15	300			100	150	1,975	15	600			100	250	3,075		
224½	Middle Sister	5	300			100	200	2,500	20	700			100	250	3,175		
223½	Lower Sister	5	1,000			50	150	2,100	5	2,000			200	400	5,350		
218½	Upper Portland Bar	10	500			50	100	1,375	5	1,500			100	250	3,425		
216½	Portland Landing	10				100	200	2,250	10				200	400	4,400		
215	Lower Portland Bar	10				100	300	3,200	10				200	500	5,350		
211½	Lexington Bar	30				100	150	1,975	30				150	300	3,525		
205½	Hurricane Bluff Bar	10				100	250	2,725	10				150	400	4,275		
203½	Saint John's Bar	20						200	20				100	200	2,350		
197½	Upper Canton Shoal	10	3,000			50	150	3,150	10	7,000			100	250	6,925		
194½	Lower Canton Bar	15				100	250	2,775	15				300	500	5,650		
191½	Nixon & Park's Land'g Bar				100			200				200			400		
189	McGuire's Bar	25				50	150	1,800	25				100	200	2,400		
188½	Bar above Prairie Bluff	10		200	100			450	10		400	200			800		
185½	Prairie Bluff Shoals	10	500			50	150	1,900	10	2,000			100	200	3,250		
182½	Midway Landing	5			50			150	5			100			250		
175	Upper Evans Bar	20				100	300	3,300	20	500			100	400	4,500		
172	Lower Evans Bar	10				50	200	2,125	10				100	300	3,200		
169	Yellow Jacket Bar	5	500			100	200	2,450	5	1,000			100	300	3,650		
168½	Hobbs's Island Bar	40				100	250	3,025	40				150	300	3,625		
164½	Pursley Creek	5		500	100			625	5		1,000	100			1,000		
163½	Black's Bluff Bar	15			100	100	300	3,450	15			200	200	350	4,375		
162	Tait's Bar	5				50	100	1,125	5				100	200	2,200		
160½	Wilcox Bar	10			50	50	200	2,225	10			100	150	300	3,525		
158½	McNeill's Bar	10			100	100	200	2,450	10			200	100	200	2,650		
152½	Montgomery Bar	10				100	300	3,200	10				200	400	4,400		
151½	Ohio Bar	5				100	250	2,675	5				200	400	4,350		
147	Stein's Island	40				100	250	3,025	40				200	300	3,750		
140	Bates's Bar	10				100	250	2,725	10				200	300	3,450		
135	Hanie's Island	20				500	1,000	9,450	20				1,000	1,500	14,710	Map sheet F.	
130½	Stabler's wood-yard	5			50			150	5			100			250		
128	Silver Creek Bar	5			100	100	300	3,350	5			150	200	400	4,650		
111	Mrs. Gray's Bar	15	500			100	300	3,500	15	1,000			150	350	4,350		
103½	Flynn's Bar	20						200	20				100	200	2,350		
100½	Shackelford's Bar	5				200	300	3,400	5	500			250	400	4,725	Map-sheet G.	
96½	Jewett's Bar	30						300	30				100	200	2,450		
94	Carter's Shoal	5				100	200	2,200	5				200	250	2,925		
90	Williamson's Bar	5						50	5	2,000			400	250	4,425		
85	Choctaw Bar	15						150	15				500		1,400		
82½	Mathewson's Bar	25						250	25				500	200	3,400		
79	Tait's Shoals	50				1,000	200	4,900	50				3,000	400	11,800		
73	Earle's Shoals	30				1,000		2,800	30				2,000	250	7,675		
71½	Wreck of steamer Aberdeen	5						550	5				500	250	4,175	Includes removal of 2 wrecks.	

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List of bars, shoals, reefs, and other obstructions to navigation upon the Alabama River, &c.—Continued.

Map-distance from Mobile.	Name of locality.	Channel 4 feet by 200 feet.							Channel 6 feet by 150 feet.							Remarks.
		Logs to remove.	Gravel and sand excavation.	Soft-rock excavation.	Solid-rock excavation.	Brush and stone protection.	Jetties and dams.	Cost.	Logs to remove.	Gravel and sand excavation.	Soft-rock excavation.	Solid-rock excavation.	Brush and stone protection.	Jetties and dams.	Cost.	
Miles.		*No.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Lin. ft.*	*Dollars.*	*No.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Lin. ft.*	*Dollars.*	
60½	Cut-off	10	500	.....	.....	200	400	4,650	10	1,000	.....	.....	300	600	7,050	Map-sheet H.
59½	Old cut-off	.....	.....	.....	.....	500	.....	1,250	.....	.....	.....	500	500	.....	1,250	
44½	Mouth Alabama River	20	.....	.....	.....	.....	.....	200	.....	.....	.....	.....	.....	.....	200	Between cut-off and mouth of river.
	Total	.....	.....	.....	.....	.....	.....	204,310	.....	.....	.....	.....	.....	.....	395,455	

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The amount appropriated for the examination not contemplating an instrumental survey of the obstructions found upon the river, it will be necessary, in many cases, to have a survey made before determining a plan of improvement.

Therefore to the foregoing total cost must be added an amount sufficient to cover this item, also an amount to provide for the removal of logs and trees obstructing the sides and lodged in the bottom of the river in the long reaches of open water not covered in the tabular estimate.

The total estimate will then stand as follows:

For channel of 4 feet by 200 feet.

Total cost from tabular estimate	$204,310 00
Additional logs to remove, 500, at $10	5,000 00
Superintendence, survey, and contingencies, 10 per cent	20,431 00
	229,741 00

For channel of 6 feet by 150 feet.

Total cost from tabular estimate	$395,455 00
Additional logs to remove, 500, at $10	5,000 00
Superintendence, surveys, and contingencies, 15 per cent	59,318 25
Total	459,773 25

The Alabama River is crossed by two railroad-bridges, neither of which offers any obstruction to the passage of steamboats, so far as learned. The first one noted, that of the South and North Alabama Railroad, crosses the river at a point 6 miles above Montgomery, is a combined wood and iron trussed bridge, supported on brick piers, with openings on each side of turn-table pier of 90 feet at low-water; elevation of track above high-water 10 feet, oscillation of river at this point 53½ feet.

The coffer-dam yet remains above the center pier, narrowing the actual opening to 82 feet; this is dangerous to boats passing through when the stage of water covers the pile-heads from sight, rendering the passage dangerous to that extent.

The other bridge, that of the Western Railroad, crosses the river about 8 miles above Selma, on an iron truss-bridge, supported upon piers of wrought-iron columns, based on masonry; draw-openings 120 feet between masonry, at low-water; elevation of track above high-water, 9 feet; oscillation of river, 55 feet.

Bridge located on a long straight reach of river; no cause of obstruction to navigation.

Owing to a return of fever contracted while upon the river and the consequent debility following, I was obliged to suspend office-work about the 1st of December last, which was not resumed till the 1st of February, since which period the pressure of other office-work has not allowed sufficient time to mature fully any statement of the commercial interests involved.

The present commerce on the river is much restricted during the low-water season, the smaller class of steamboats only running, they finding difficulty in making their way to Montgomery, and seldom going as high up as Wetumpka during the season of low-water.

The citizens along the entire river manifest much interest in the proposed improvement, looking forward to its early consummation as the means of placing the entire river-section of the State upon an equal footing with the more favored portion having railroad-connections. With an improved condition of the river, bringing about a more efficient steamboat-service, the discriminating rates of freight upon the river would disappear, and products of the rich river-lands, now valueless to the producer, would become profitable under the cheapened cost of transport to market.

The production also of the more valuable products would be stimulated, and the tide of commerce again restored to the natural and cheaper water-lines of transportation.

I beg to express my indebtedness to the officers of steamboats plying upon the river for their invariable kindness and interest manifested in forwarding the objects of the examination, and to the citizens of Wetumpka, Montgomery, and Selma for their kind interest.

To Mr. W. H. McCurdy, who was engaged as pilot for the examination, I am indebted for minute and accurate knowledge of the river and for faithful co-operation in its prosecution.

Respectfully submitted.

GAVIN B. YUILLE,
Assistant Engineer.

Bvt. Maj. A. N. DAMRELL,
Captain of Engineers, U. S. A.

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I 8.

WATER-COMMUNICATION BETWEEN THE MISSISSIPPI RIVER AND ATLANTIC OCEAN, ACROSS THE PENINSULA OF FLORIDA.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., April 3, 1876.

SIR: In the river and harbor act of March 3, 1875, the sum of $50,000 was appropriated for the examinations and surveys directed to be made during the fiscal year at the forty-six localities designated in the act. But the amount appropriated did not prove to be sufficient to enable this office to comply with so much of the act as required surveys and examinations to ascertain the practicability and cost of an inland water-communication between the Mississippi River and the Atlantic, along the Gulf of Mexico and across the peninsula of Florida, which, from their extent, would have necessarily consumed much of the appropriation, to the exclusion of a number of other localities requiring examination. To supply this omission I beg leave to submit herewith copies of parts of reports heretofore submitted to Congress upon the results of the surveys for a canal-route across Florida, made in compliance with the acts of March 3, 1826, and August 30, 1852, together with copies of reports from Captains C. W. Howell and A. N. Damrell, Corps of Engineers, made in September, 1873, in reference to portions of the route in question. These last reports are replies to instructions from this office, based upon a request from the mayor and chamber of commerce of Savannah, Ga., for information upon the subject. I also transmit herewith two maps, explanatory of the routes described in the above reports.

In the report of April, 1874, from the Senate Committee on Transportation-Routes to the Seaboard, two routes are pointed out as naturally suggesting themselves for moving the grain-trade of the Mississippi from New Orleans to the Atlantic, along the Gulf coast and across the peninsula of Florida, one a coast-line through Lake Pontchartrain or Lake Borgne, and thence, by means of short canals and land-locked bodies of water, along the Gulf to the Florida coast, and by canal to the Atlantic; the other an exterior line, along which steamers and their tows passing out of the mouths of the Mississippi might coast along the shores of the Gulf to a western terminus of a Florida canal at either the mouth of the Suwannee or of the Withlacoochee or at Tampa Bay.

Of the three routes to which public attention has been directed for opening a channel from the Mississippi near New Orleans, in order to pass inland to Mobile, that of Bayou Manchac, Amite River, and Lake Maurepas into Lake Pontchartrain, or from near Carrollton direct to the lake, or from a point some 12 miles below New Orleans into the head of the Mexican Gulf Canal, and through that to Lake Borgne, the latter would perhaps be the most economical. With the exception of a connection with the Mississippi, where a lock will be required, this route already affords, it is said, 7 feet of water at all times. To ascertain the cost of deepening this to 9 feet, the depth required for grain-barges, it will be necessary to ascertain the cost of a suitable lock at the Mississippi end of the Mexican Gulf Canal, the cost of extending the jetties at the lake end of the same canal, and of deepening the whole canal to that depth, the cost of excavation necessary through the flats between Lake Borgne and Mississippi Sound, and that of deepening Grant's Pass.

For the inland water-route, between Mobile and Pensacola Bays, an

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examination was made in 1833, provided for by act of Congress, with the view of forming an estimate of the probable cost of opening a navigation between the two bays to boats drawing 7½ feet. The route recommended was up Bon Secours Bay and River, and thence by a through-cut to Bear Creek; thence through Bay Lalande into Perdido Bay, and from Perdido Bay, by a cut, either into the Great Lagoon or into Bayou Grande, an arm of Pensacola Bay. The estimated cost at that time was $1,000,000 for the route through Great Lagoon, and $2,000,000 for the route into Bayou Grande. These estimates would probably have to be doubled at the present prices to secure a 9-foot navigation.

Passing eastward from Pensacola Bay, the route would follow Santa Rosa Sound; through this sound into Choctawhatchee Bay and River, thence through Saint Andrew's Bay into Wetappe Creek, and either by canal into Dead Lake and Apalachicola River about 30 miles from its mouth, or through Searey's River and Lake Wemico to near the mouth of this river, about 5 miles from Apalachicola.

The length of this continuous line of bay, river, and canal navigation is, from the Mississippi to Grant's Pass, about 100 miles, and from Grant's Pass to Apalachicola River about 200 miles; 21 miles of which last distance would have to be cut through a comparatively flat, sandy country, and 35 miles would require to be widened and deepened to afford a channel of 9 feet. It has been roughly estimated that $7,000,000 might probably establish the route between Mobile and Apalachicola.

An act of Congress of March 3, 1826, directed a survey to ascertain the most eligible route across Florida, by which to connect the Atlantic with the Gulf of Mexico, by a canal for the transit of boats, and also to ascertain the practicability of a ship-canal. Two routes were directed by the act to be examined, one from Saint Mary's River to Apalachicola River or Bay; the other from Saint John's River to Vassasousa Bay, (mouth of Suwannee.)

The Saint Mary's route, as surveyed in compliance with this act, commenced at Bell River, five miles above the entrance of this arm of the sea into Saint Mary's River, and thence ascended to the head of Alligator Creek, one of the upper branches of Saint Mary's River; from this point it ran through Okefenoke Swamp, crossed in succession the Upper Suwannee, the Alapaha, and the Withlacoochee Rivers, the latter a tributary of the Suwannee. From this point the route took its course to the Ausilla River, and thence descended to Saint Mark to follow afterward the general direction of the coast to Apalachicola Bay.

Respecting this route the survey showed that on account of the elevation of the intervening ground between the mouth of Bell River and Alligator Creek, it would most likely become indispensable to follow the circuitous course of the river, which would increase the distance about 36 miles.

The survey shows a distance of 42 miles from Bell River to the mouth of Alligator Creek, whilst the distance measured along the bank of Saint Mary's River is about 78 miles.

The Okefenoke Swamp, extending along the top of the dividing ridge, would not, it was said, afford any natural reservoir of consequence, and 45 miles of canal summit-level would have to depend entirely on water collected in artificial reservoirs. The report upon the survey states that the nature and extent of this swamp give reasonable hope that by a proper system of drains the standing water in the marshes may be made available, by collecting it in sufficient quantity to supply the summit

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and middle sections of the canal, but the expense would be great. From the Suwannee to Saint Mark, the canal would be sufficiently provided with water from the Suwannee and the Ausilla; but the route would have to wind around the spur on which Tallahassee stands.

The distance from Bell River to Saint Mark, following the surveyed line, is 183 miles; keeping along the banks of the Saint Mary's River, up to the mouth of Alligator Creek, it would be 219 miles. Should it be desired to connect the Gulf with Saint Mary's River at the head of tide, the eastern termination of the canal would be in the vicinity of Barbour's plantation, (Trader's Hill,) and the length of canal would be reduced about 28 miles. The elevation of the summit would be about 150 feet above low-tide in the Atlantic; the whole amount of ascent and descent 300 feet, or supposing the summit-level sunk 20 feet below the summit-ground, 260 feet.

The second route provided for by this act of Congress, to connect Saint John's River with Vassasousa Bay, (Wacassassa Bay,) commences at the mouth of this river in the Atlantic, and terminates at the mouth of Suwannee River in the Gulf of Mexico. It ascends the Saint John's to the mouth of Black Creek, and reaches, at Kingsley's Pond, the head of this tributary; hence in its course to Sampson's Pond it crosses the Florida Ridge, and then descends Santa Fé River to its junction with the Suwannee, from which point it follows the Suwannee down to its entrance into Vassasousa Bay, or it may be carried from some point of the Suwannee, before reaching the Gulf, to Saint Mark's and thence to Apalachicola. The whole route from tide-water in Black Creek to tide-water in Saint Mark's River will be about 168 miles; the ascent and descent together, 224 feet. Natural reservoirs can be relied on to supply the lockage at the dividing point, while it was thought that recourse must be had to filtration from the ground to keep the trunk of the summit-level replenished.

The size of canal contemplated in these surveys was 33 feet at bottom and 5 feet deep, with locks 100 feet long by 14 feet wide. At the present time first-class Mississippi grain-barges require a depth of 9 feet. They are about 220 feet long and 40 feet beam, and would require locks of at least 250 feet by 50 feet. A canal suitable for the transit of such boats would therefore appear from this report to be impracticable along the two routes just described, for want of water.

But in the proceedings of the Senate Committee on Transportation-Routes to the Seaboard, (Senate Doc., Report 307, 43d Congress, 1st session,) examination of Col. P. H. Raiford, page 775, the first of these two routes—the Saint Mary's route—is differently presented. The canal-route there described is east from Saint Mark's forty miles, through marsh-land to Finnahaw River; thence 30 miles to the point of intersection with the Suwannee, no portion of which would require a deeper cut than 10 to 16 feet for a depth sufficient for the largest boats and barges of the western rivers. Then to ascend the Suwannee by three or four slackwater-dams about 60 miles above the point where the canal from the Finnahaw would reach it, to a point thirty-odd miles from the Saint Mary's; there ascend to the Okefenoke Swamp plateau by three locks; cross the plateau with a maximum cut of 25 feet and descend to the Saint Mary's by four locks. The supply of water from Okefenoke Swamp is assumed as ample for all purposes of a canal.

The depth of cutting, however, here estimated through the summit is much less than would accord with the levels of the survey above described.

In the river and harbor act of August 30, 1852, provision was made

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for the completion (revision) of this old line of survey, or a new line, as might be deemed expedient, for a ship-canal across the peninsula. In compliance with this act the survey of a new line was undertaken, the extreme points of which were the headwaters of the Saint John's and Tampa Bay.

The route surveyed leaves the Saint John's at the mouth of the Weekivah, a small stream four miles below Lake Monroe. Following the valley of this stream nearly to its source, as direct a course as the nature of the ground will admit of is thence taken to the low depression of sand-hills in the summit-divide of the interior; from thence the course is direct to the valley of the Hillsborough, which it follows until the proper depth of water in that stream is reached. This line is about 115 miles long. The size of canal was fixed at 60 feet wide at surface, and 6 feet deep, with locks 110 feet by 16 feet. The total elevation to be overcome from the headwaters of the Saint John's to the summit of the canal is 107 feet. From Hillsborough River to the summit, the elevation is 119 feet. Giving the locks a lift of 8 feet will make fourteen locks between Saint John's and summit and fifteen between summit and Hillsborough, to which add a lock at each terminus, making, in all, thirty-one locks.

The supply of water for this canal is derived from the headwaters of the Ocklawaha (Hawk Creek) and of the Withlacoochee, but as these streams have their origin in several large sheets of water south of the canal-line, and receive their supply almost entirely from them, it was proposed to make these lakes tributary to the canal. They are about 35 in number, vary in depth from 10 to 45 feet, and have an aggregate area of about 15,000 acres. They may be connected and made tributary to a canal by cuttings of an aggregate length of about 7 miles. In addition to this, there are extensive swamps and marshes, usually covered for eight months of the year with from 1 to 3 feet of water, which can be connected with these lakes, the whole of which, it was estimated by Lieut. M. L. Smith, Corps of Topographical Engineers, the officer in charge of the survey, would make an area of 198 square miles that could be made tributary to the summit-level of a canal. Should this be the case, there would appear to be an adequate supply of water for a canal of even greater dimensions than that then proposed.

Lieutenant Smith estimated at that time (1853) the cost of a canal of the above dimensions between the Saint John's and valley of the Hillsborough, with its accessories, at $3,700,000.

A greater depth can be given to a canal, and a more direct course can be obtained, by following the valley of the Ocklawaha and connecting with the lower portion of the Saint John's. In this case the sand-ridge cut by the summit of the route just described will be avoided, and the summit-level could be reduced some 18 or 20 feet. There would be the same sources of supply of water, with the addition of other lakes near the head of the Withlacoochee. The length of canal to be constructed would be increased about 50 miles, but the whole transit across the peninsula shortened by about 20 miles. There is believed to be on this route a supply of water sufficient for a canal of the depth of 12 feet. The junction with the Saint John's would be near Pilatka.

From the foregoing a judgment may be formed of the nature and extent of the surveys required to ascertain the most advisable location and plan, and the probable cost of the several portions of the routes in question. Should Congress see fit to require a full investigation of

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the subject, an appropriation of at least $20,000 would be required for the purpose.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. ALPHONSO TAFT,
Secretary of War.

REPORT OF CAPTAIN C. W. HOWELL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., September, 1873.

GENERAL: In compliance with instructions contained in Engineer Department letter, dated Office of the Chief of Engineers, Washington, D. C., July 22, 1873, I have the honor to report on that portion of an inland-water route (suitable for first-class grain-barges) between the Mississippi River and the Apalachicola River, lying within and adjacent to my district of operations, viz, from the Mississippi River to Mobile Bay.

The best route is described as follows: From New Orleans down the Mississippi River, about 12 miles, to the head of the Mexican Gulf Canal; thence through the canal to Lake Borgne; thence to Mississippi Sound, through that and Grant's Pass to Mobile Bay. This route now affords 7 feet of water at all times and all places, except between the head of the canal and the river.

To make connection at this point necessitates the construction of a lock, plans for which have been drawn. But I have not succeeded in getting estimates of cost from the canal company.

On a rough estimate, I set the cost of completing this 7-foot route from the Mississippi to Mobile at $250,000.

The route so far is feasible from an engineering point of view.

For first-class grain-barges a depth of channel of 9 feet is required. The figures are as follows:

DIMENSIONS, ETC., OF BARGE.

Beam	40 feet
Floor	38 "
Length	220 "
Will carry	1,500 tons freight
Will carry bulk corn—on deck	30,000 bushels
Will carry bulk corn—in hold	25,000 "
Total	55,000 bushels

On a draught of 9 feet.

The lock at the Mississippi end being made of suitable size to admit such barges, they can be taken through to Mobile Bay at high spring-tides, occurring about six days each month; to take them through at other times it will be necessary, first, to extend the jetties at the lake end of the Mexican Gulf Canal to 9 feet of water in the lake, and further excavate between them at a cost I have not the data for estimating.

2d. To excavate a channel on an average 2 feet deep, through the flats between Lake Borgne and Mississippi Sound, for a length of several miles. The length can be ascertained from Coast Survey charts not yet issued.

3d. Grant's Pass will, to the best of my information, have to be deepened.

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Commerce using the route must pay toll through the canal and through Grant's Pass.

As to advantages to accrue from opening this route and prolonging it to Savannah, I have but this to report as my opinion:

1st. So long as the port of New Orleans is open, it is preposterous to think that Savannah can draw, over the route here reported upon, any portion of the commerce of the Mississippi River, either export or import.

2d. In time of war, supposing the Gulf ports blockaded by a hostile fleet, and Savannah not, this inland-water route would be invaluable.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF CAPTAIN A. N. DAMRELL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., September 19, 1873.

GENERAL: By letter from the Engineer Department, dated July 22, 1873, I am instructed to procure such information (without incurring expense) as would enable me to submit my views as to the feasibility, advantages, probable cost, &c., of a proposed navigable inland-water route, suitable for first-class grain-barges, between the Mississippi and Apalachicola Rivers; and, in compliance with these instructions, I have the honor to submit the following report on that part of the route lying within my district of operations, namely, from the Mississippi Sound to Apalachicola River.

The route from New Orleans, I suppose, would be through a canal into Lake Borgne, thence into Mississippi Sound, and through Grant's Pass into Mobile Bay. From here I propose the following location: Across Mobile Bay into Bon Secour Bay; thence either through Bear Creek or through the Little Lagoon into Perdido Bay; from here, through the Grand Bayou, into Pensacola Bay and Santa Rosa Sound; through this sound into Choctawhatchee Bay and River; thence through Saint Andrew's Bay into Wetappo Creek; from here, either by canal into Dead Lake and Apalachicola River, about 30 miles from its mouth, or through Searey's River and Lake Wemico to near the mouth of said river, about 5 miles from Apalachicola.

The distance by this route, forming a continuous line of bay, river, and canal navigation from Grant's Pass to Apalachicola River, is about 200 miles, 21 miles of which would have to be cut through a comparatively level, sandy country, while about 35 miles would require to be widened and deepened, to afford a channel of 9 feet depth at mean low-water, with a width of 100 feet through its entire length.

The country along this route is very thinly settled, and without incurring considerable expense it is impossible to obtain any correct information on which to base a close estimate of the cost of this work.

From all the data at present at my command, I calculate that an outlay of about $7,000,000 would be necessary to permanently establish this route, with a channel as above stated.

On the inclosed map, the proposed route is plainly marked out, indi-

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cating also such changes in location as on closer examination might prove preferable.

Such a route would, in my opinion, be entirely feasible as a work of engineering, but, with its proposed terminus, it possesses no commercial advantages as long as the ports of New Orleans and Mobile are kept open, and would no doubt prove a financial failure.

Such a work could only become of national importance with a terminus in a good harbor on the Atlantic coast.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

EXTRACT FROM THE REPORT OF THE BOARD OF INTERNAL IMPROVEMENT UPON THE RESULTS OF SURVEYS, MADE IN COMPLIANCE WITH ACT OF CONGRESS OF MARCH 3, 1826, OF ROUTES FOR A CANAL BETWEEN THE ATLANTIC AND THE GULF OF MEXICO, PRINTED IN DOC. 102, TWENTIETH CONGRESS, FIRST SESSION, AND, WITH ADDITIONS, IN DOC. H. R. 185, TWENTY-SECOND CONGRESS, FIRST SESSION. SEE ALSO DOC. H. R. 61, TWENTY-THIRD CONGRESS, FIRST SESSION, FOR REPORT ON SURVEYS FOR A CANAL TO CONNECT MOBILE AND PENSACOLA BAYS.

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INVESTIGATIONS OF THE SEVERAL ROUTES OF A CANAL ACROSS THE PENINSULA OF FLORIDA.

From the foregoing description of surveys, it can be inferred that the routes through Saint Mary's River and through Black Creek are the only ones for a canal destined to connect the Atlantic with the Gulf of Mexico.

Respecting the Saint Mary's route, it has been shown that on account of the great elevation of the intervening ground between Bell River and Saint Mary's River at the crossing point, and also between this point and the mouth of Alligator Creek, it would most likely become indispensable to follow the very circuitous course of the river, a circumstance which would increase the distance by about 36 miles; indeed, the survey shows a distance of 42 miles from Bell River to the mouth of Alligator Creek, while the computed distance measured along the bank of Saint Mary's River amounts to about 78 miles.

Again, it has been stated that the Okefenoke Swamp, stretching on the top of the dividing ridge, did not afford any natural reservoir of consequence; and that 45½ miles of canal would have to depend entirely on water collected in artificial reservoirs. On this score, the nature and great extent of this swamp give reasonable hopes that, by a proper system of drains, the standing water in the marshes would be made available by collecting it in sufficient quantity to supply the summit and middle sections of this canal, but the expense would be great, though partially compensated by the increased value of the land thus reclaimed.

From the Suwannee to Saint Mark, the canal would be sufficiently provided with water from the Suwannee and the Ausilla; but, as it has

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been stated before, this route would have to wind around, south of the surveyed line, the spur on which stands the district of Tallahassee.

The distance from Bell River to Saint Mark, in following the surveyed line, is 183⅜ miles; but, in keeping along the bank of Saint Mary's River, the route of canal, from the junction of Bell River up to the mouth of Alligator Creek, would be about 36 miles longer, or 219 miles.

However, were it in contemplation to connect the Gulf with the Saint Mary's River, at the head of tide, the eastern termination of the canal would be in the vicinity of Barbour's plantation; and should it prove practicable, and within reasonable expense, to descend from Okefenoke Swamp into Saint Mary's River, in following a direct course, the distance to Saint Mark would be 155 miles; but should it be found indispensable to follow the river, in order to descend from Okefenoke Swamp to tide-water, the distance to Saint Mark would be 192 miles.

In either case, the elevation of the summit-level will remain the same, 152 feet above low-tide in the Atlantic, and 148 feet above low-tide in the Gulf; the whole amount of ascent and descent will be 296 feet, measured from a level 4 feet above low-water in the Atlantic to the level of low-tide in the Gulf; or, rather, 256 feet, by supposing the summit-level sunk 20 feet below the summit-ground.

Before entering into particulars relating to the route of canal through the headwaters of Black Creek and Santa Fé River, it is necessary to determine where should be assumed the eastern and western terminations of the canal. Respecting the eastern, it would seem that the mouth of Saint John's should be selected as the most eligible, but such a debouch would not be without inconveniences.

1st. Small boats cannot, without great danger, stem the current of Saint John's River above its mouth, and sea-vessels require strong and very favorable wind to cross over the shifting bar and to make head against the bold current of either ebb or flood tide. These circumstances render the entrance of the Saint John's not accessible in adverse weather, dangerous when the wind does not assist sufficiently against the current, and precarious on account of the necessary concurrence, or rather relation, which must take place between the wind and the current, to facilitate the sailing in or out of the river.

2d. Such difficulty of access would, in time of war, prove very injurious on a coast which, south of the Saint John's, presents no shelter of any consequence. The safest for vessels bound to the canal would be to make, first, the harbor of Saint Mary's, and there to wait for propitious weather.

3d. It has been stated, in describing the surveys executed in relation to the Saint John's route, that a canal from a point opposite the mouth of Black Creek to the mouth of Pablo Creek would require, above low-tide, an excavation averaging 28 feet in depth, or 26½ miles in length. This section of canal would save a distance of about 16 miles, when compared to the natural channel of the river. This advantage cannot balance the expense for the construction of this portion of the canal. Indeed, in keeping this line of canal nearer to the bank of the Saint John's, the excavation would not prove so great, but the distance then would not become materially lessened.

4th. It has also been shown that a section of canal from the fork of Black Creek to the mouth of this tributary of the Saint John's would involve into an extraordinary excavation, and be deprived of a sufficiency of water. Besides, when compared to the natural channel of Black Creek, it would not shorten the distance more than by 4 or 5 miles.

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5th. A canal from the fork of Black Creek to the mouth of the Saint John's, following the banks or margins of both rivers, would not procure considerable advantages over the natural channels, which enjoy the benefit of tides, nor could it remove the difficulty of ingress from or egress to the sea. A vessel having made into the Saint John's can then ascend as far up as the fork of Black Creek, head of tide-navigation, for the depth of water over the bar at the mouth of Black Creek is 6½ feet at low-tide and 8 feet at high-tide, the latter being little more than the depth over the Saint John's Bar at medium low-tide. Therefore, should the mouth of the Saint John's be assumed as the debouch into the Atlantic of the water-communication across the peninsula, a canal from this point to the fork of Black Creek would afford no sufficient advantage to warrant its expense of construction.

6th. If taken into consideration that the inconsiderable depth of water over the Saint John's Bar, as also the insufficiency of water on the summit-level, preclude the idea of a ship-channel, the transshipping of cargo from sea-vessels to boats, or from boats to sea-vessels, will remain the same, whether the canal terminates at the mouth of the Saint John's or at the fork of Black Creek. Therefore, while convenience does not strictly necessitate the extension of the canal to the mouth of the Saint John's, considerations of economy lead the board to recommend the fork of Black Creek, head of tide-navigation, as the eastern termination of the canal.

Now, it remains to determine whether the debouch of this communication into the sea must be at the mouth of Saint Mary's Harbor, or of the Saint John's. To the local inconveniences just enumerated in regard to the latter, are to be added those relative to the inland navigation along the coast. Indeed, the lower part of the Saint John's is connected with Saint Mary's Harbor but by the natural crooked channel called Indian Passage, which admits the transit of row-boats only; and, in the present state of things, the natural inland-water communication parallel to the coast can be considered as terminating at Saint Mary's. This commodious harbor, presenting on the bar a depth of 13½ feet at low-water and 19½ feet at common high-tide, is susceptible of defense, and derives a great importance from the circumstance of being the only good harbor from the boundaries of Georgia to Cape Florida.

From this it can be inferred that the mouth of the Saint John's is not virtually connected with an inland-water communication parallel to the coast, while Saint Mary's Harbor is an interesting station, at which terminates the natural inland navigation from the Chesapeake to Florida—navigation which could be extended to the head of Saint John's River by opening a canal in the direction of the inland passage from Saint Mary's to the Saint John's. This canal would procure to the water-communication across the peninsula the most eligible debouch into the Atlantic, and would, besides, form the southern link of our inland-water communication parallel to the coast, in the same manner as the Dismal Swamp Canal forms the northern link of the same navigable line. Here, it must be remarked, that the Saint John's, in descending from the south, effects a parallel direction to the coast, and that south of its head-branches the territory of Florida will most likely not soon be settled, on account of the sandy and swampy nature of the soil. Therefore, the upper parts of the Saint John's may be considered as being the southern extremity of the line of natural water-communication parallel to the coast; at least there appears at the present time no plausible motive to have it extended farther south.

These considerations induce the board to recommend Saint Mary's Har-

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bor as the debouch into the Atlantic of the contemplated communication, and, to this effect, to open a canal for sloops from Saint Mary's Harbor to the Saint John's.

Let us pass now to the investigation relative to the western termination of the canal. It has been shown, in the description of the surveys executed on the Saint John's route, that the canal would debouch into the Suwannee, at or in the vicinity of the mouth of Santa Fé River. From this point the canal has either to descend to the Gulf in following the Suwannee, or to take a direction to Saint Mark. In the first case, the distance to the Gulf would be 55 miles; in the second, about 95 miles, (from computation.) Thus, shortness of distance and an unobstructed navigation in the Suwannee seem at first to be in favor of the former course, and more especially when it is taken into view that a canal for boats might end at the mouth of the Santa Fé, where might commence a commodious steamboat-navigation. But, most unfortunately, the access from the sea to the mouth of the Suwannee is much obstructed by oyster-banks, and the approach to the shore impeded by the extensive shoal making along the coast from Espiritu Santo to Saint Mark; sail-vessels drawing more than 5 feet cannot at high-tide hazard to steer for the mouth of the Suwannee, and even this draught would be too great during the prevalence of northerly winds. To this must be added, that from the bay of Espiritu Santo to Saint Mark the coast presents no shelter where vessels could lie at anchor and wait for propitious weather. From these considerations, it can be concluded that by using the Suwannee as a navigable stream a steamboat-navigation might be established down to the mouth of this river, but hence to Saint Mark, Pensacola, and New Orleans the passage by sea would become very precarious, on account of the circumstances just enumerated. Therefore, to obtain a permanent communication and a more commodious debouch into the Gulf the only alternative is to terminate the canal into the harbor of Saint Mark. It will be remembered that Saint Mark's River affords, at its mouth, 8 feet of water at high-tide, and that a good anchorage is found inside of the outer bar for vessels drawing 10 feet. To this must be added, first, that the coast east of Saint Mark is not provided with any inland natural channel parallel to it, while, to the west of Saint Mark, the great depth of water along the shore and various intervening sounds will facilitate, if not a complete inland navigation, at least a pretty safe one along the coast, many good anchorages being found from Saint Mark to Pensacola; second, that the vicinity of Saint Joseph's Bay will secure to the anchorage of Saint Mark the efficient protection of our armed vessels; third, in fine, that the debouch of the canal being near to the thriving settlement of Tallahassee, will, in time of war, become supported by a population more compact than probably would be afforded by any other district of Florida, and that it will also insure at all times the communication of this district with the Atlantic States.

The western termination of the canal being thus determined, it remains to devise as to the route of the section of canal which would connect the Santa Fé with the harbor of Saint Mark. The board entertain no doubt as to its practicability, and had the line from the mouth of the Withlacoochee to Saint Mark been run in conformity with the instructions, as a line of canal instead of a line of levels, the survey executed in that quarter would have afforded positive data upon which would rest the practicability of a canal from the Santa Fé to Saint Mark. However, the surveys performed along the Santa Fé River and the Suwanne, procure individual facts which will assist the board in pointing out the section of canal route under consideration.

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The bank of the Santa Fé, near the place (Natural Bridge) where the river sinks under ground, is 68 feet above the Gulf. Six miles above this place the rise, caused by freshets, is represented to be 14.22 feet above the common stage of water. The quantity of water yielded by the river at Rocky Ford, 14 miles above the Natural Bridge, has been found to be 176.6 cubic feet per second; the river was then 11.2 feet below high-water mark. From these facts it can be concluded that by damming the Santa Fé, at a favorable place above the Natural Bridge, the whole water of the river will, at common stage, become available, and yield at least 176.6 cubic feet per second, besides the resources of a reservoir which will extend several miles toward Rocky Ford. This supply will be more than necessary to feed 50 miles of canal through sandy ground.

The Suwannee at Charles Ferry, where it is crossed by the military road from Saint Augustine to Tallahassee, has its bank 52 feet above the Gulf, and, therefore, 16 feet below the bank of the Santa Fé, near the upper end of the Natural Bridge. This shows that there is a fall between these two points; and, though the surveys do not exhibit precisely the respective elevation of the streams at Charles Ferry and at the Natural Bridge, yet this fall remains well ascertained; whence results the practicability of a canal from the latter point to the other. The distance will be about 50 miles, the ground easy, and the supply of water sufficient.

The Ausilla, where crossed by the Saint Mary's line of levels, is 47 feet, and its eastern bank 73 feet above the Gulf. Therefore, by assuming, on this river, and below the latter point, a convenient termination with regard to the Suwannee, in the vicinity of Charles Ferry, the two streams will easily be connected by a canal descending to the Ausilla, and well supplied from the Suwannee. The distance will be about 45 miles.

From the Ausilla to Saint Mark, the distance will be about 20 miles, and, in this direction, a canal will receive from the Ausilla a large supply of water, amounting, as stated before, to 217.8 cubic feet per second.

Such is the route which the board recommend to connect the Santa Fé with the harbor of Saint Mark. The whole distance will be about 115 miles; the descent to low-tide in the Gulf (low-tide which is supposed to be about 4 feet above low-tide in the Atlantic) is assumed 62 feet from Rocky Ford; the supply of water will be largely furnished by the Santa Fé, the Suwannee, and the Ausilla. With regard to the ground, it will not necessitate much extra excavation, the digging will generally be easy; however, on many portions of great extent, it will be necessary to carry the line of canal through marshes and cypress-swamps. A great waste of water is to be expected from filtration through the sandy upper stratum, lying on a substratum of porous and rotten limestone, and also from evaporation; but the means of supply are very great; and, during heavy showers, so frequent under the climate of Florida, the trunk of the canal will receive, from filtration of the ground, very copious additional supply.

It remains now to investigate the section of canal which would be the continuation of the preceding one to the fork of Black Creek, that is to say, to the head of tide-water on the Atlantic.

This section comprehends the summit-level, and has to rely for supply mainly on the natural reservoirs of Sampson's and Kinsley's ponds; the former 126.4 feet, the other 171 feet, above low-tide in the Atlantic; about 4 feet less above low-tide in the Gulf.

Kinsley's pond, on the eastern side of the ridge, might be assumed as

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the summit of the canal, were its supply of water sufficient, but this supply is far from being adequate to the object. Indeed, this reservoir would have to provide for about 14 miles of canal, (shortest distance between Sampson's pond and a point 6 miles above the fork of Black Creek, where a reservoir might be obtained in the valley of Bull Creek,) and for lockage at the summit. The canal being supposed to be 33 feet at the bottom, and to have a depth of water of 5 feet, it will require per month and per mile 120,000 cubic yards—absorption, filtration, and evaporation being taken into account; the 14 miles will therefore require for nine months 15,120,000 cubic yards. Owing to the nature of the climate, the navigation must be open throughout the year; but, in this calculation, nine months only are assumed, because it is expected that, during three months of heavy rain, the freshets, in the head branches of Black Creek and Santa Fé River, will supply these fourteen miles of canal.

Assuming the passage of boats per day to be 45 each day, or 90 both ways, the number throughout the year will be 32,850, which, at the rate of one and a half lock-full, or 623 cubic yards per each boat, will require 20,465,550 cubic yards of water per annum. The lock is here supposed to be 100 feet long, 14 wide in the clear, and 8 feet lift.

Adding together the two items of expense of water, it will be found that 35,585,550 cubic yards of water are necessary to supply, during the whole year, the prism of the canal and the lockage at the summit.

The superficies of Kinsley's pond is 77,714,100 square yards; the depth has not been ascertained, but is represented to be about 6 feet. This reservoir cannot, therefore, be deemed to contain more than 15,428,000 cubic yards of water; a quantity which, if available, would not be half of what is necessary. But such supply cannot be drawn from the pond, the localities presenting no probable means to have this pond replenished as fast as partially drained; indeed, the country sloping around it is of small extent in superficies, and its outlet, dry in summer, is not considered as yielding more than 10 cubic feet of water per second during the rainy season. This pond seems, therefore, to be fed mainly from filtration, inasmuch as it receives no water-course, and, as is well known, the loss of a reservoir throughout the year by evaporation is greater than the rain falling on its surface. During the rainy season the rise of the pond is represented as being sometimes 2 feet; and, in damming the outlet, this elevation can be considered as the maximum depth of available water; this would produce a supply of 5,142,466 cubic yards of water.

This result shows that Kinsley's pond alone is inadequate to procure the whole water required. Therefore, the summit-level must be kept lower, and tried at the elevation of the reservoir, immediately below, and which lies on the western side of the ridge.

This reservoir is Sampson's pond, 45.4 feet below Kinsley's pond; its superficies is 16,362,777 cubic yards, and its rise, during the rainy season, has been ascertained to be 3 feet; therefore, the minimum supply to be drawn from this pond can safely be estimated at 16,362,777 cubic yards, more especially should the outlet to this reservoir be dammed. This supply added to that of Kinsley's pond will give 21,505,443 cubic yards for the quantity of available water drawn from both ponds, a quantity sufficient to supply the lockage.

By keeping thus the summit-level at a less elevation, a deep cut will become indispensable through the top of the dividing ridge; but, taking into consideration that the streams of Florida, in this quarter, receive few tributaries, and are chiefly fed by filtration, the board anticipate

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that this deep cut will procure the advantage of feeding, by means of filtration, the prism of the portion of canal forming the summit, a prism which would thus become an artificial reservoir.

This deep cut, in following a direct course from Kinsley's pond to Sampson's pond, would require, under the very top of the ridge, a depth of 122.1 feet, by assuming the bottom 10 feet below the medium level of Sampson's pond, or 116.4 feet above the Altantic. But the line of levels from Orange Lake to Sampson's pond shows that the top of the ridge, east of Little Santa Fé pond, or the 25th mile from Orange Lake, is but 158 feet above the Atlantic; while in the direction of Kinsley's pond and Sampson's pond the elevation is as much as 237.5 feet; therefore, at this place, the top is 79.5 feet higher than it is in the vicinity of Little Santa Fé pond. This circumstance indicates that the ridge becomes depressed between the outlet of Kinsley's pond and the southern head-branch of Santa Fé River; the summit-level must consequently take this course, in order to lessen, as much as practicable, the depth of the cut through the ridge. Thus, the cut will commence in the valley of Bull Creek, at a point 116.4 feet above the Atlantic, 54.6 feet below the surface of Kinsley's pond, and 41.6 feet below the summit of the ridge, in the vicinity of Little Santa Fé pond; hence it will take its course toward this pond, to terminate into Santa Fé River, at a point 10 feet below the medium level of Sampson's pond, or 116.4 feet above the Atlantic. By following the depression of the ridge, the greatest depth of the cut will not probably exceed 60 feet, and the length of the summit-level will be about 25 miles. The eastern end, in Bull Creek, will be 3 miles east of Kinsley's pond, 9 miles from the fork of Black Creek; the western end, in Santa Fé River, will be about 5 miles above Rocky Ford, and 5 miles from Sampson's pond.

From these premises, it is seen that, by assuming the summit-level 116.4 feet above the Atlantic, the two ponds will furnish the necessary water for lockage; but with respect to the prism of the level, about 25 miles in length, it has to rely entirely on the resources derived from filtration through the ground. Therefore, the practicability of the canal rests altogether on this point.

The following observations, made by the board during their examination of the peninsula of Florida, lead them to anticipate a favorable result:

1st. The sandy upper stratum and the rotten limestone substratum will facilitate the filtration to a high degree.

2d. The ponds on the summit of the ridge are chiefly kept full by filtration.

3d. The numberless ponds, of various sizes, scattered everywhere on the surface of the peninsula form a strong indication of the facility afforded by the ground for the transmission through it of water to inferior levels.

4th. The main streams of the peninsula have few tributaries; they are, however, flush during the warm season, and suddenly swelled by accidental heavy showers. This shows that they must chiefly receive their supply from filtration.

Should, however, the foregoing facts be deemed not sufficient to insure the result, though anticipated, yet not positively warranted by the board, the practicability of the canal would then remain altogether questionable till the sinking of shafts to the depth of the cut should have tested the degree of reliance to be placed on the foregoing conjectures.

From the eastern end of the summit-level to the fork of Black Creek the distance will be about 9 miles, and the fall 112.4 feet, to a level 4

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feet above low-tide in the Atlantic. This portion of the canal will be fed by a reservoir in the valley of Bull Creek, by the south prong of Black Creek, and by the water previously used for lockage at the summit.

From the western end of the summit-level to the Natural Bridge, the length of the canal will be about 19 miles, and fall 50.4 assumed down to Rocky Ford. The Santa Fé, the north fork of Santa Fé, and the water previously used for lockage at the summit, will supply this portion of canal.

The whole length, and the ascent and descent, of the route of canal from the fork of Black Creek to the harbor of Saint Mark will be as follows:

	Miles.	Feet.
From the fork of Black Creek to the eastern end of the summit-level	9	
Ascent from 4 feet above low-tide		112.4
Summit-level, length about	25	
From the western end of the summit-level to the Natural Bridge, distance.	19	
Descent		50.4
From the Natural Bridge to Saint Mark, at low-tide in the Gulf, distance.	115	
Descent		62.0
Whole distance and ascent and descent	168	224.8

Let us compare, now, this route with that of Saint Mary's. The distance by the latter from the head of tide in Saint Mary's River to low-tide in the harbor of Saint Mark will be 192 miles in following the bank of the river, and the whole amount of ascent and descent 256 feet; therefore, respecting distance and expense of lockage, the Saint John's route has the advantage.

Both routes will require expensive excavations to supply the summit-level with water. But on the Saint John's route the item of lockage is secured, and the prism of canal, which is to be supplied by filtration, is only 25 miles long; while on the Saint Mary's route, draining and filtration must procure the water required both for lockage and for 45 miles of canal. In such a state of things, the Board consider the chances of greater expense and of insufficiency of water as against the Saint Mary's route, and, therefore, recommend the Saint John's route.

This route has, besides, the advantage of being susceptible of affording an early and partial result, by terminating either in the Suwannee or the Santa Fé, where, a point being assumed as the head of steamboat navigation, a water-communication through the canal and the Suwanne would become established between the Atlantic and the Gulf.

With regard to a sloop-canal, connecting the harbor of Saint Mary's with the Saint John's River, its main object is independent of a canal across the peninsula. Should the Saint Mary's route be preferred, its importance would remain the same, but it would increase should the Saint John's route be adopted.

Respecting the cost of the work, the Board are not now prepared to undertake this part of their task. The appropriation made by Congress has been entirely expended in making the surveys herein described; all which were strictly indispensable to ascertain (in a country to this time but superficially known in relation to its topography and hydrography) the facts, and procure the data upon which the selection and practicability of a route should be predicated. It remains now to fix the canal on the ground, to plan the work and all its details, and thence to devise the elements upon which must rest the estimate. Minute surveys will consequently become necessary to enable the Board to frame

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the estimates required by the resolution of Congress. The board, therefore, shall here close up this subdivision of their report, and pass to that which relates to the navigation along the western coast of Florida.

* * * * * * *

SUMMARY.

The coast on the Gulf of Mexico, between Tampa Bay and Appalachie Bay, cannot be approached by vessels drawing more than 5 feet; in this latter bay 8 feet can be carried at high-tide to Saint Mark's. Besides, the ridge of the peninsula of Florida has a mean elevation of 150 feet above the ocean, and its top does not offer, at any place, either natural reservoirs or heads of streams adequate to the supply of a canal having very large dimensions; therefore, a ship-canal, destined to connect, through the peninsula, the Atlantic with the Gulf of Mexico, is not practicable.

The heads of Santa Fé River and of Black Creek present to a canal for boats the best passage across the summit of the ridge. Natural reservoirs in this vicinity will supply the lockage at the dividing-point, while it is anticipated that filtration from the ground will keep replenished the trunk of the summit-level.

In this direction, a canal from the fork of Black Creek to the mouth of the Santa Fé would connect the Saint John's with the Suwannee; therefore, the Atlantic with the Gulf. Such a canal would be about 78 miles in length, and the ascent and descent together 214 feet.

But the Suwannee being much obstructed at its mouth, and having no harbor at its entrance into the Gulf, it will be expedient to continue the line of canal from the Santa Fé to the harbor of Saint Mark. The whole route from the fork of Black Creek to Saint Mark's, or rather from tide-water in Black Creek to tide-water in Saint Mark's River, will be 168 miles long, and the ascent and descent together 224 feet.

With a view to an uninterrupted inland navigation, parallel to the coast, from the Chesapeake to the head of St. John's River, it will be necessary to open a sloop-canal from the harbor of Saint Mary's to the Saint John's. Respecting the coasting navigation from Saint Mark's to Lake Pontchartrain, it will be rendered secure, safe, and commodious by means of the following improvements:

First, a canal along Crooked Creek, from Ocklockony River to a convenient point in Saint George's Sound; through by this sound and the canal the Apalachicola will become connected with Saint Mark's; secondly, the cleaning and deepening of the Santa Rosa Sound, at the meeting of tides; thirdly, a canal from the bay of Pensacola to that of Mobile, through the Great Lagoon and the river Bon Secour; fourthly, the deepening of the Pass Au Heron, between the eastern point of Dauphin Island and the main. Lake Pontchartrain can be connected with the Mississippi by a canal, which has been projected, at or near New Orleans, and by Bayou Manchac.

This bayou, the rivers Plaquemine and La Fourche, can be rendered navigable at any stage in the Mississippi; and they deserve consideration, as offering the only outlet through which, in time of freshets, the Lower Mississippi might be relieved in the discharge of its waters.

All which is very respectfully submitted.

BERNARD,
Brigadier-General, Member of the Board of Internal Improvement.
WILLIAM TELL POUSSIN,
Captain Topographical Engineers, Assistant to the Board.

WASHINGTON CITY, *February* 19, 1829.

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EXTRACTS FROM REPORT OF LIEUT. M. L. SMITH, CORPS TOPOGRAPHICAL ENGINEERS.

[Printed in Ex. Doc. No. 1, Senate, Thirty-fourth Congress, first session, page 434.]

WASHINGTON, *May* 1, 1855.

* * * * * * *

PRACTICABILITY OF A CANAL ACROSS THE PENINSULA OF FLORIDA.

The party was organized and work carried on under the following orders:

BUREAU OF TOPOGRAPHICAL ENGINEERS,
Washington, October 30, 1852.

SIR: The duties assigned to you are the survey of a canal-route across the peninsula of Florida. The extreme points of said route are the waters of Espiritu Santa Bay and the headwaters of the Saint John's.

Having ascertained a place on the first sufficiently sheltered, and having a convenient access to the deep water of the bay, you will carefully examine the country between that position and the headwaters of the Saint John's, as a point to which about 2 feet can be carried in navigating that river.

Then you will carefully mark out the line between these two points.

Then you will make an accurate survey of this line, so as to exhibit the route in plan and profile. Then, for about every 300 yards of this main line, or more frequently or not so frequent, as the ground shall in your judgment require, you will make offsets to this main line, each not less than 200 yards, which offsets are to be as carefully surveyed as the main line, so as to exhibit plan and profile, and so as to connect these offsets and profiles with the profiles of the main line, and with the same plane of reference.

J. J. ABERT,
Colonel Corps Topographical Engineers.

Lieut. M. L. SMITH,
Fort Brooke, Tampa, Fla.

Espiritu Santa Bay being one of the extreme points of the proposed route under the instructions, the determination of the other will first be spoken of.

In examining the Saint John's for the purpose of ascertaining to what point up the river 2 feet water could be carried, the following information was obtained: From the mouth 11 feet can be taken up to Pilatka, 10½ to the mouth of the Ocklawaha, 8½ entering Lake George, 6 in leaving it, 4½ into Lake Monroe, 1½ to 2 in leaving it, and a further decrease of depth into Lake Harney. These depths vary, particularly in the upper portions of the river, when it is swollen from rains; thus, 6½ feet may then be found at the outlet of Lake Monroe, nearly the same at its inlet, and some 6½ to 7 at the outlet of Lake Harney; but those depths only are regarded which can be relied on during all seasons. Lake Monroe was therefore considered the limit of permanent 2-foot navigation; hence the other extreme point of the line mentioned in the instructions would be at or below this lake.

The precise point at which the proposed canal should connect with the river was decided from the following: Lake Monroe is shallow, being about 10 miles long by 4 wide; has a depth of from 12 to 14 feet in the middle, and shoals gradually to the shore; there is consequently no point at which the requisite depth is very near shore, and all parts of it are open and exposed to storm-winds. To have the connection anywhere on the lake seemed liable to two objections: First, that the lock at the junction would be some distance from shore—hence present some difficulty of construction. Second, that the entrance to it would be liable to be choked from the effect which any such jetty

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would necessarily have upon the drift of the lake. Further, nothing is apparently gained by making the junction at the lake; and as the canal would practically be but a continuation of the river, the two should be united at a point offering natural facilities for it. Such a point is found anywhere below the lake, where the river is again narrowed to a proper width to give a well-defined channel, and has firm banks; the shoal at the outlet to Lake Monroe is at the same time avoided. The valley of a small stream, called the Weekivah, emptying into the Saint John's some four miles below Lake Monroe, offers a rather straight and convenient depression for a canal from Tampa Bay, and as at its junction the river has sufficient width and depth, the proposed route has been made to follow down the valley of this stream and join the Saint John's at this point, which fulfills all the necessary conditions for the connection of the canal with the river.

The two extreme points being thus fixed, the general position and direction of the route becomes so, subject to such variations in directness as the physical features of the country and facts developed by actual survey require.

The accompanying maps, constructed on a large scale, together with a minute profile of the country, render any but a general description of the line unnecessary.

DESCRIPTION OF THE LINE.

The general profile across the peninsula shows a gradual swell both from the Atlantic and Gulf coasts to the middle, where is found a range of broken sand-hills, varying in height above the average level of the interior from 100 to 125 and 150 feet, and in width from 1 to 3 and 4 miles. The country is flat, thickly sprinkled with cypress and baygall swamps, and much of it to the eye presents no distinct or well-defined system of drainage.

On the eastern side of the sand-hills there are two main depressions, touched by the line, which drain in opposite directions and overlap each other: first, the valley of the Saint John's, draining northward; next, the valley of the Kissimmi and its tributary head-streams and lakes, draining south. On the west of the sand-hills there is a gradual slope to Tampa Bay, sufficiently indicated by the direction of the various streams.

In passing from the valley of the Saint John's into that of the Kissimmi, the latter is cut by the line so near its head-sources that the slight divide separating them requires no unusual depth of cutting, and the only serious natural obstacle along the line is presented in the sand-hills spoken of. This range was examined for several miles to the right and left of the point selected for cutting it; one point only of it was found where the width and depression was as favorable as that decided upon, (known in that country as at the source of Horse Head Creek,) but the increased distance given to the line caused it to be rejected. The greatest depth of cutting required here will be 80 feet, and the ridge, as far as could be detected by boring and other examinations, consists wholly of sand. The height of the established summit-level is 113 feet above ordinary low-water at the mouth of the Hillsboro River, and 101 feet above the water in the Saint John's at the point of junction, giving 14 locks of 8 feet lift on one side of the summit-level, and 15 (2 having over 8 feet lift) on the other side. The soil is sufficiently favorable not to present any unusual difficulty. Proceeding from the Saint John's the excavation would be in sand, mixed with clay and fine

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gravel in greater or less degree, until reaching Lake Weekivah, where gravel, as far as noticed, disappears. Sand and clay, the latter not in large proportion, will thence constitute the soil to be excavated for the remainder of the line, varied a little by gravel and alluvion along Hillsboro River. With these few remarks descriptive of the line, I proceed to the consideration of those points directly touching the practicability of a canal along it.

A canal may be regarded as a stream conducted artificially from a higher to a lower point by a series of steps or levels, the source of the stream being the highest or summit level. If the length of this level is not short compared with some one near it, (in which case additional sources of supply are sought, and in general are readily found, since new streams constantly present themselves as you descend,) it is sufficient in the discussion of the subject to show a proper supply of water for the summit-level, and it carries with it proof of a proper supply for the levels below, since the water from leakage and lockage, which constitute the main expenditure, passes into the lower levels. In the case under consideration, the summit-level is, with one exception, the longest level on the line; and if a supply adequate for this can be shown, the practicability of a canal will be proven, for all other points connected with a canal have reference to a greater or less cost of construction merely.

For the purpose of being as clear as possible in the discussion of an adequate-supply, the subject will be taken up in the usual order, to wit: First, determine the supply of water required; second, show how and from whence this supply is to be obtained.

The unit of measure taken, and denominated the water-prism, is the entire contents of the summit-level, which is 21 miles + in length.

SUPPLY OF WATER REQUIRED AT SUMMIT-LEVEL.

This ought to be sufficient to meet an expenditure due to the following requirements:

1st. Losses from evaporation.
2d. Losses from filtration and absorption.
3d. Losses from leakage at lock-gates.
4th. For the use of locks, according to the demands of trade, upon the summit-level.
5th. First year, for filling summit-level.
6th. Losses arising from emptying portions of a reach, for repairs of various kinds, from breaches, &c.

The expenditure from the more important of the causes enumerated being dependent upon the dimensions given to the canal and locks, the following communication from the Bureau establishing them is inserted:

WASHINGTON, *May* 16, 1853.

SIR: * * * * Your consideration and plan will be bestowed upon the supposition of a canal 60 feet wide at top and 6 feet deep; locks 110 feet long, 16 feet wide, (in the clear.)

J. J. ABERT,
Colonel Corps Topographical Engineers.

Lieut. M. L. SMITH,
Topographical Engineers.

LOSS FROM EVAPORATION.

Loss from evaporation must, from the circumstances attending and governing, be imperfectly arrived at. It is influenced by temperature, by dryness or moisture of the atmosphere, and very particularly by

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currents of air. Temperature, alone, would probably cause less inequality of variation than either of the other two-named causes, since it is more uniform in its action over a large extent of country, and the changes are not so frequent and sudden.

The hygrometrical condition of the atmosphere will depend much upon the country the currents of air have passed over; for example, all are familiar with the exceeding dampness of the sea-breeze and corresponding dryness of the air on the western prairies.

Whether the air be still or in motion makes the greatest difference, shown by the rapidity with which any article is dried when exposed to a brisk breeze, as compared with the time required when the air is comparatively still. During some experiments, made in England by Dr. Dalton, evaporation was said to be increased 50 per cent. by opening a window of his room. The uncertainty arising from this element alone must be apparent, when it is considered that, in point of actual fact, currents of air never remain the same two consecutive half-hours, but are continually changing in direction and varying in force. Nevertheless, certain conclusions have been arrived at, which we proceed to state.

Dr. Halley fixed the evaporation at London, during an ordinary summer's day, at $\frac{2}{10}$ of an inch, which is equal, for a month of thirty days, to 6 inches; and the annual evaporation at 48 inches.

The result of the experiments made by Mr. Cotte at Montmorency, near Paris, (as given by Gauthy in his work on canals,) was to determine 41.575 inches as the annual evaporation; and 5.315 inches as that of an ordinary summer-month.

It was ascertained on the Languedoc Canal by Mr. Pinn, the engineer, that during ten and one-half months the average loss from evaporation monthly, over and above the rain that fell, was 3.044 inches; by averaging the quantity of rain along the entire line, a quantity is educed for evaporation equal to 5.330 inches. (Andreossi.)

In a report made by Colonel J. J. Abert, Topographical Engineers, to the governor of Maryland in 1838, upon the subject of a canal to connect the Chesapeake and Ohio Canal with the city of Baltimore, the probable evaporation for that climate during the ten business months was assumed at 67.20 inches; an average of 6.72 inches per month.

The Board of Engineers of the Morris Canal adopted 51 inches for the maximum loss of water by evaporation during the eight months (from April to December) it could be navigated, or 6.375 inches per month.

In the Encyclopedia Britannica is found a table constructed by Dr. Dalton, from which, knowing the dew-point and temperature, the rate of evaporation can be obtained.

For that portion of Florida under consideration the dew-point has been assumed at 55° Fahrenheit. I am not aware of any observations that have been made to determine what this point is ordinarily, and can only judge of it from the average heights of the thermometer at 9 p. m., when dew is usually perceptible. The Medical Department, through its officers at the different posts, have obtained numerous and accurate meteorological observations, which have been kindly furnished me by Dr. R. H. Coolidge, now in charge of that branch of the Medical Bureau. From these, the mean annual temperature at three different points near the line of survey is as follows:

Tampa Bay	72°.41 Fah.
Fort Mead, on Pease Creek	71°.00 "
Fort Capron, or Pierce	74°.11 "

The last two of these points are south of the line of survey, and prob-

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ably of a somewhat greater mean temperature. Most of the line, too, is north of Fort Brooke, which should also be considered.

The mean annual temperature for the entire line is assumed at 70°, and it is thought to be rather below than above the true temperature.

Applying, then, the dew-point, 55°, and temperature, 70°, to Dr. Dalton's table, we find a daily evaporation of 0.255 inch, or 7.45 inches monthly.

For the purpose of comparing the evaporations established for different points, they are recapitulated:

Evaporation at London, 6 inches per month.
Evaporation at Montmorency, 5.315 inches, ordinary summer-month.
On Languedoc Canal, 5.330 inches per month.
J. J. Abert, for climate of Baltimore, 6.72 inches per month.
On Morris Canal, 6,375 inches per month.
For Florida, by Dalton's table, thermometer 70°, 7.458 inches per month.

During dry weather, thermometer averaging 86° Fahrenheit during the entire twenty-four hours, there is, under favorable circumstances, in the latitude of Washington, an evaporation during that time of 0.3 inch, or 9 inches per month. Eighty-six degrees is much above the mean temperature of the latitude under consideration, and, with the thermometer at that height, evaporation would go on during the twenty-four hours; evidently, then, 9 inches is too much to allow for. In deducing the quantity 7.458 inches by Dalton's rule, it is believed the dew-point assumed is rather below than above the true one, which would increase the result obtained; hence it is concluded that, practically, 7.458 inches will represent the monthly evaporation with sufficient accuracy.

Evaporation, it must be remarked, does not constitute the most important part of the expenditure of water on a canal; hence, whether it is more or less by 1 or 2 inches per month, is really not of special importance, for if the supply and expenditure are so nearly equal as to depend upon evaporation for difference, it ought to be conceded at once that there is not an adequate supply.

The number 7.458 inches is accordingly taken, and it gives a loss from this cause of a prism—say every nine months, or $1\frac{1}{3}$ water-prisms per year.

LOSS FROM FILTRATION.

This is a loss constantly varying with the nature and compactness of the soil, and a result which would apply to one section would by no means be applicable to another. As the losses both from this cause and evaporation can in general only be known by the diminution of water in the canal, it has been usual to combine them together, and estimate the sum at so many water-prisms per year.

In the case of one canal only (the Languedoc) has a distinct loss by filtration been given; but it has not been found to apply to similar works in this country, owing, probably, to the greater care taken in its construction; hence the method of combining the two losses seems to be the only one that can well be pursued, and that gives but an approximate result.

Experiments made on the Chesapeake and Ohio Canal by Mr. Fisk show that it loses a little more than $1\frac{3}{4}$ its water-prism monthly from these two causes. Now, the evaporation assumed as proper for that climate by Colonel Abert has been seen to be 6.72 inches monthly; from which it results that filtration is about fourteen times greater than evaporation.

Experiments on the Erie Canal seem to indicate a loss from filtration

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still greater than this; but, being given in connection with leakage from locks as well as losses from evaporation, the approximate quantity cannot be given. As connected with this part of the subject, the following extract from J. J. Abert's report to the governor of Maryland is introduced:

From experiments made on the Erie Canal, and communicated to me by that distinguished engineer, Mr. J. B. Jervis, it would appear that the least loss, from observations made at various places, was 100 cubic feet per mile per minute. This was not the measurement of loss from a distinct cause, but from all united—leakage of locks, evaporation, and filtration. The dimensions of this canal are 40 feet water-surface—28 at bottom and 4 deep—which give for its prism of one mile 26,595.5 cubic yards. The loss of 100 cubic feet per mile per minute is equal to 160,000 cubic yards per mile per month; or, supposing the navigation to continue nine months, (in that climate,) the total loss would be equal to 54 times its water-prism per year; adding to this the loss of the prism in the canal at the closing of the navigation, gives a total loss of 55 of its prisms of water for all causes, except the demands of the locks for its trade.

These observations were made about 1833 or 1834; the canal had been in use a number of years, and its loss from filtration may fairly be considered to have been much less at that time than when first constructed. There is no good explanation of this difference of loss in the two canals, unless it be that Erie, being built first, was not as well constructed.

If the Chesapeake and Ohio canal be considered as a fairer sample of such works in this country than the Erie, and its losses taken as a basis of estimate, the following is deducted for loss from filtration:

Evaporation per year has been found to be $1\frac{1}{3}$ prisms; 14 times $1\frac{1}{3}$—say 19 prisms loss due to filtration.

The correctness of this result evidently depends upon similarity of soil in the two cases; and the question naturally arises, how will fine, compact sand, mixed with small proportions of clay, retain water? In answer, two facts are stated: 1st. That this soil, in connection with small brush, makes a secure and tight dam. 2d. That around waste or flood gates and other openings in earthern dams, where leaks are almost unavoidable, it is among the best things to render these openings water-tight. One reason of this would seem to be that, each grain of sand being solid, water can only find its way through the small openings or interstices between them; these interstices soon become filled by any extraneous matter brought by the water in filtering through, and the whole becomes a solid mass.

The summit-level established on this line is, with the exception of a very short distance at its western extremity, entirely in excavation. Now, experiments seem to show that water can always be found at a distance below the general surface of the country not exceeding from 4 to 6 feet. This would bring the water-line in the summit-level below the depth at which water is found to permanently remain in the soil, so that instead of losing, the canal would receive a supply from the soil. This fact is again referred to under the head of "infiltration," and in connection with certain data, which, it is considered, render further remark at present unnecessary.

It is not, therefore, thought that *nineteen prisms* per year is too small a loss to be allowed for filtration, and is accordingly taken.

LEAKAGE AT LOCK-GATES.

A liberal allowance should be made for this item, since, unlike filtration, it is least while the locks are new, and increases from year to year as the canal is used, until the gates are replaced.

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The dimensions of the locks on the Chesapeake and Ohio Canal are nearly the same as given for the canal under discussion; and the observations made upon them may be applied in the present case, particularly as it is a work executed in our country; and the manner in which, in its various details, it has been constructed, may be considered a sample of the way in which similar works would be completed. Mr. Fisk, the chief engineer of this canal, made many observations upon the leakage of the locks during a period of suspended navigation, when the gates were kept carefully closed for several weeks while repairs were being made. The result was to fix the leakage due to a lock at twelve lockfuls per day. Engineers in this country have usually considered this as the proper amount to be allowed for leakage when calculating the supply of water needed. As it is a matter to be determined entirely from observation, there seems to be no reason for supposing a different quantity would be nearer the actual loss.

Twelve lockfuls leakage per day per single lock would give 24 lockfuls per day, drawn from the summit-level, due to the locks at either end, or 8,760 lockfuls per year, which is equal to 3.85 water-prisms.

AMOUNT REQUIRED FOR LOCKAGE.

It is to be understood, in speaking of this amount, that reference is still had to the summit-level only, with its two locks, one at either end.

This is the only portion necessary to be considered, since the lower reaches receive not only what is drawn from this for the purposes of trade, but what arises from leakage at lock-gates and accidental wastage.

The quantity required for lockage is dependent upon trade, which necessarily varies from year to year; hence no absolute amount can be stated as being neither more nor less than what will be required. The rule is to allow for the greatest possible activity of a lock during a certain number of hours, and take the amount of water expended during that time as the amount due to lockage. Thus, say that, on an average, a lock will be in use twelve hours a day during the year; that twelve boats per hour can be passed through, and each boat, in passing the summit-level, requires two lockfuls; the quantity drawn from the summit-level is at once known. There are three points, then, to be considered. First, the average number of hours per day that a lock may possibly be used; second, the average number of boats that can be passed through a lock per hour; third, the average quantity each boat may require for passing the summit-level.

First. The average number of hours per day a lock may be used. It has been usual to take twelve as the number, and it is probably great enough to cover every case in the country. The only possible exception, it is believed, may be the Erie Canal, on which the locks are in use day and night for weeks at a time, particularly during the fall, just previous to suspended navigation, and while the western produce is on its way to market.

If the connection of the Atlantic and Gulf by a canal across the peninsula of Florida is of sufficient importance to justify the construction of one, allowance for an active trade through it should be made, for it is intended to be a highway to the Gulf commerce similar to the straits of Florida at present. Instead of twelve, twenty hours will be taken as the daily average time for the working of locks.

Second. The average number of boats that can pass through a lock per hour.

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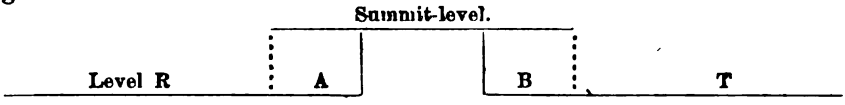
For a single hour a boat might, it is probable, be passed through every three minutes; in point of fact, however, each boat consumes from four and a half to five minutes; if four minutes be taken as the average, it is considered that the error will be on the safe side; this makes 15 boats per hour.

The average quantity assigned to the passage of a single boat into and out of the summit-level, has varied with different engineers according as they have supposed boats to pass in opposite directions with more or less regularity. To illustrate this the two extreme cases are given:



1st. Suppose a boat on the level R, and one on the level T, present themselves respectively at the locks A and B, both locks being empty; they enter the locks, which are then filled, and both pass into the summit-level: thus far a prism of lift (or lockful) has been drawn from the summit-level for each boat; they pass, and each proceeds into the lock which the other has left full; the locks are then exhausted and the summit is passed. It is plain that in this instance but two lockfuls (or one to each boat) has been drawn from the summit-level; this is called an alternate passage, and is the case in which the least water is used by a boat in a passage, namely, one lockful.

Alternate passages of boats could never be relied on except in cases of a canal having a trade equal to its utmost capacity, one-half flowing in one direction and the other half in the opposite; this can never be the case, and would require a regularity of movement on the part of boats not attainable by trains on railways. This case evidently cannot govern. Let us now take the other extreme case. Suppose, after the alternate passage just spoken of, two boats to present themselves at the lock on the level R to make their passage, and none on the level T. The first boat finds the lock A empty, passes into it, the lock is filled, the boat then moves out and is on the summit-level. The second boat presents itself at A, which is full and must be exhausted before it can be received; this being done, the boat enters, A is again filled, and the second boat joins the first. They then proceed to B, which is empty; this must be filled for the first boat to pass into, and then drawn off to lower the boat to the level T. The second boat, consequently, finds B empty, and another prism of lift is required for it to be passed in and be lowered. For this case four lockfuls have been required, two for each boat, and the locks left in the condition they were before the passage. This case is termed a consecutive passage, and undoubtedly shows a consumption of water to pass each boat which exceeds what would be found true in practice. Now the consumption may vary anywhere between what is shown in these two cases; and as the order in which boats will pass the summit-level must be a matter of chance, it is considered that the only absolutely safe allowance to make for each boat will be the maximum expenditure; two lockfuls are therefore allowed to each boat in passing the summit-level.

We have, then, the following quantities for the calculation: 15 boats per hour for 20 hours per day during 365 days, at two lockfuls per boat, $15 \times 20 \times 365 \times 2 = 219{,}000$ lockfuls, equal to 95.38 water-prisms.

The requirements of the canal per year can now be stated, the unit taken still being the water-prism of the summit-level.

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	Water-prisms.
For evaporation and filtration	20.33
Leakage at lock-gates	3.85
Lockage	95.38
For filling canal first year	6.00
Total	125.56
Or, after first year	119.56

In obtaining the consumption of a canal for the purpose of deducing the required supply, it has been necessary to consider the summit-level only, (since the main losses from this level pass into the lower ones and compensate for the losses taking place there.) If, therefore, a supply of water adequate to the summit-level can be shown, we at the same time show a supply for the entire canal; for, as we descend, many additional streams are crossed which can be commanded if necessary.

By reference to the profile-sheets, the waters which must supply the summit-level are found at an elevation of 128 feet above the waters of Tampa Bay; the dividing ridge must of course be passed at an elevation somewhat lower, in order to command these waters for a supply; and this elevation has been assumed at 115 feet above Tampa Bay, or 15 feet below the water forming the sources of the Withlacoochee and Ocklawaha. This level is maintained as long as is practicable and not lose for feeders any of the small streams crossed on the course. The propriety of this is evident, since the higher the level the less excavation there will be; hence, less expense. As before stated, the length of the summit-level thus established is 21+miles.

SOURCE OF SUPPLY.

Having determined the amount of water needed by the canal, the question presents itself next in order, can this amount be found, and can it be shown that it will be supplied yearly?

1. The profile map shows that no streams or lakes east of the ridge of sand-hills can be made use of; west of it there are Hawk Creek, (a tributary of the Ocklawaha,) the Withlacoochee, (at the point of crossing mainly a swamp,) and Grassy Creek; this latter fails during the dry months.

As both Hawk Creek and the Withlacoochee have their origin in several large sheets of water lying in the same region of country south of the line, and receive their supplies entirely from them, together with rains when they occur, the safer and it is believed the only way will be to throw the streams out of consideration and argue directly upon these natural reservoirs themselves.

In following up the headwaters of the Withlacoochee and Hawk Creek south, within a distance of about 14 miles, some thirty-five lakes are found, varying in extent of area from 2 miles square to one-eighth of a section. These lakes range in depth from 10 to 45 feet, and have an aggregate area of 15,000 acres. They could be connected and made tributary to the canal by cutting about 7 miles; and in almost every case the ridges separating the lakes do not rise more than from 3 to 5 feet above the surface of the waters to be joined. It is proposed to command the water of these lakes to a depth of 6 feet when connected.

Bordering these lakes, and in many instances in reality connecting them, are extensive swamps and marshes, usually covered for eight months of the year with water from 1 to 3 feet in depth. The area over which they extend will be about four times that mentioned for the lakes, and when the latter are connected will be likewise tribu-

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tary to the canal. Let the swamps be supposed to average 1½ feet in depth for nine months of the year, we have then, lying during the entire year in these natural reservoirs or lakes, and subject to control, 16,000 acres of water 6 feet deep, equal to 129 water-prisms of summit-level, and swamps holding water equal to 96 prisms more, making a supply equal to over twenty-one months; if to this is added the quantity held in swamps and marshes that can be made available, it equals the requirements for four and a half months more.

This is mentioned and given in this unit to show to what extent the headwaters of the two streams mentioned will serve as a great natural reservoir for the use of the canal, and it results that twenty-one months' supply for the canal in full operation can be retained. These lakes, ponds, &c., are, in my opinion, mainly, if not entirely, supplied by rains and surface-drainage; hence, it still remains to be shown that these natural reservoirs can be maintained and not exhausted by use. The case would be quite different were these lakes, &c., fed by springs and living streams; hence, not susceptible of being materially reduced.

The country that would be made tributary to the summit-level of the canal, if the lakes were connected as indicated, has an area of 198 square miles; the main drainage from this area will be by the two streams mentioned; but, in addition, many other ponds, marshes, &c., together with one stream, will empty their waters into it.

In the following investigation I shall limit myself to ascertaining the amount of supply which can be relied upon as never failing, and which will be therefore a minimum amount, the least that in any supposed case can be counted upon as certain. Should this prove to be more than sufficient for the requirements of the canal as determined, it will evidently be unnecessary to carry the investigation further, and show what surplus would probably exist under favorable circumstances.

The area that can be made tributary to the summit-level is 5½ townships, or 126,720 acres.

There is some uncertainty as to precise quantity of rain to be relied on annually. Points quite near, however, to the line of survey have been taken, and the observations for rain compared; it results that at Tampa Bay the yearly fall is 57 inches, at Fort Meade 35 inches, at Fort Pierce 73 inches, Jacksonville 58 inches, giving an average for the four places of 56 inches. These observations are too limited to afford with much certainty a correct general rule; hence the annual fall of rain will be taken much below the average of the places given, to wit, 45 inches. The inquiry now arises, what proportion of this 45 inches downfall rain can be made available for the canal? A precise answer to such a question can never be given until the works have been actually constructed and the amount collected absolutely gauged; hence it is only by giving experiments made at different localities, and the conclusions thence drawn, that even a partially satisfactory answer can be made.

If data were far more extensive and minute than exist, engineers would still be obliged to exercise very much their own judgment in fixing upon any proportion of downfall of water that could be collected, as soil, climate, and a broken or flat country would vary the results for any except the given places.

William Cubitt, an English engineer, states as his opinion that about one-half the annual fall of rain can be stowed in reservoirs and made available; a proportion very high, considering the land in England is generally cleared, under cultivation, and level, conditions calculated to cause much of the surface-water to be absorbed and evaporated before draining off.

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It was calculated by Sutcliffe that little more than one-third of the rain which fell could be got into the summit-level of the Rockdale Canal from the area tributary to it. The experiments of Mr. J. B. Jervis, made with reference to the construction of the Chenango Canal, in the State of New York, led to the conclusion that about 40 per cent. of the fall could be collected; the rule of engineers has been to allow that one-third could be collected, and this has been followed by all in this country. Under ordinary circumstances there is no doubt but this rule would require to be modified for a more southern climate, as the tables of Mr. Jervis show that seven out of the twelve months are decidedly affected by the cold of winter; the proportion of rain collected during these seven being nearly three times greater than during the other five, which include the hot season of summer.

Thus the proportion of rain and snow collected from November to May, inclusive, was	.686
From June to October	.246
From June to October, by a second table	.319

For a climate such as Florida's, where there is no winter, it seems pretty evident that the rule of one-third should be modified to apply, and it is thought one-fourth will be more in accordance with the experiments than *one-third.*

But there is much of the area under consideration to which neither of the rules will apply, for it has been already stated that about 16,000 acres is covered by permanent lakes and ponds, and some 64,000 is swamp, which nine months out of the twelve are under water; consequently, every drop of rain is collected as it falls on the first-named area, and for three-fourths of the year on the second.

By comparing the rain-tables at these points, Capron, Pierce, and Brooke, it appears that only $\frac{1}{11}$ of the annual fall of rain occurs during the three months referred to, when swamps are supposed dry, viz: March, April, and May; hence the quantity deducted will be $\frac{1}{11}$ of 45, $=4.09$ inches.

This leaves but 41.720 acres to which to apply the rule, that one-fourth of the rain is equal to the drainage.

The amount of rain collected on the summit-level may now be stated:

	Water-prisms.
45 inches rain on 16,000 acres amounts to	80
40.91, say 40 inches rain on 64,000 acres amounts to	286.5
$\frac{1}{4}$ of 45 inches rain on 41,720 acres amounts to	54.96
Amount	421.46

The above amounts, it is obvious, must be corrected for evaporation and filtration, as the losses in the canal have been; to determine these, it is not proposed to apply the same rules heretofore used, for the simple reason that observation shows that they do not apply, but deduce these corrections from observed losses in the lakes, ponds, and marshes while there.

To illustrate what is meant, a single case only will be cited: A lake near the 40th mile, having an area of some 130 acres, from the commencement to the close of the dry season in 1853, a period of nearly four and a half months, fell only about 5 inches; yet during the entire time there was a constant discharge, varying from 9 to 15 cubic feet per second. As the belief has been expressed that these lakes are due to surface-drainage only, it is readily perceived that no rule of evaporation that has been mentioned can apply; and I take occasion to state that what has been said of this lake will apply to every other there;

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they are plainly affected by wet and dry weather, rising during the rainy, and continuing to fall during the dry season, until long after there ceases to be any discharge at their outlets, yet never falling to the extent they ought to do, according to all the rules of evaporation. During the year they vary in height from 8 to 12 inches, those having no outlets varying, as they should, the least.

The apparent discrepancy, it is thought, may be accounted for from the constant infiltration which is going on after surface-drainage has ceased.

Lakes and ponds occupy the depressions of a country, and there is necessarily a constant, although imperceptible, drainage into them from the adjacent high ground; hence, for those having no outlet, the yearly change in height may be considered as indicating the difference between infiltration and evaporation.

In accordance with the above, the amount heretofore found will be decreased by the mean observed yearly fall of the various lakes, to wit, 10 inches.

16,000 acres covered to depth of 10 inches = 17+ water-prisms.
64,000 acres covered to depth of 7½ inches = 45½ water-prisms.

Total..... 62½ prisms.

Correcting 421.46, the number of prisms previously found, by 62.5, there is left for the annual supply expected from the lakes, &c., 358.96 prisms.

SUPPLY FROM INFILTRATION.

This is a source of supply which can occur only in few soils, and that when it is of a rather porous nature, similar to the one under consideration.

In all the investigations connected with a canal across Florida, this source has been borne in mind by the various engineers, and in 1829 and 1830 rather extensive experiments were made to ascertain what supply could be obtained from it.

These experiments being longer continued, and rather numerous, are more reliable than any made before or since, and will be made use of in the conclusions that follow.

Infiltration presupposes that the water which is leaving the surface and penetrating the earth is still above the excavation supplied by it.

If water kept its level under as well as above ground, then infiltration would continue until the entire body of water in the soil had sunk below the water-line of the canal. This, however, is not the case, since both friction and capillary attraction oppose its free flow. To what extent lateral filtration is modified by these two forces, will depend upon soil and temperature. The penetrating power of water is very great, since it is found at all explored depths; it also finds its way through the most durable and compact masonry. Infiltration will necessarily be much greater in a flat country, like Florida, than in a broken one, where drainage is rapid. Extensive swamps and few streams are found in the former; numerous streams and few or no swamps in the latter. To obtain the amount which will appear, I have taken for data experiments made in the valley of the Santa Fé, Florida, in 1831, with a view to determining this question.

The character of the soil where they were made, and the depth below surface at which infiltration commenced, correspond so exactly with what was found on the summit-level of the present survey, that I have no hesitation in applying the results to the case under consideration.

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The experiments were conducted as follows: Shafts were sunk to depths varying from 20 to 30 feet; they were pumped dry, then allowed to fill, the rise of water being noted at intervals until there was no change. Knowing the capacity of the shaft, and the area of sides and bottom, the rate of infiltration per second per square foot of filtrating surface became known. The mean of the experiments give a rate as follows:

A filtrating surface of *one square foot* yields *per hour* 0.75 *cubic foot of water.*

The question next arises, how long may this rate of infiltration be expected to continue?

In answer, the continuation of the observations is stated.

When the first experiments were made, the water rose in the shafts to within 5 feet of surface ground; this was in June. It continued at this height during the months of July, August, September, October, and into November, except portions of July and August, when the water rose about one foot higher in the shaft.

If it is admitted that infiltration will continue the same under like circumstances, then at any time during the months named its rate would have been found as has been stated.

From the above the following point is considered as established, to wit, that the water does not pass beyond the reach of a cut of 5 feet or more in depth, by sinking into the earth during four months of the year.

How long the rate of infiltration would continue when the water is passed off as supplied, can only be arrived at from experiments having this question more directly in view than the ones mentioned above. Something similar to what is desired took place, however, while the shafts were being dug, which will be stated.

It was necessary, in order to keep them free of water, to make continuous use of the pumps while the men were digging. The operation of sinking one shaft was carried on during sixty days, and out of this number there appeared to have been twenty-nine working-days.

The shaft was found filled every morning to within from 4½ to 5 feet of the surface, and required pumping out before the day's work could be commenced. The officer in charge estimated that, during a working-day of eleven and a half hours, the quantity of water thrown out by the pump was equal to nearly twelve times the capacity of the shaft, or at a rate of 1.2 cubic feet per hour per square foot of filtering surface.

Although any precise amount that may be fixed upon must be left to the judgment of the individual, still this may be safely stated—that, for all depths greater than 5 feet, the gain by infiltration will exceed the loss by filtration; and from the observations made at the shafts, this excess will continue during the months of July, August, September, October, and November; and from my own observations I am able to add the three ensuing months—December, January, and February—making in all eight months of the twelve that this source can be relied on. After February streams become sensibly diminished, ponds and surface-water generally disappear, and the country remains dry until the rains set in, which is usually in June at latest.

The summit-level established on the present line of survey has a length, in even numbers, of 21 miles. Nineteen miles of this will be in excavation, bringing the surface of water in canal below the line where filtration commenced, which is 5 feet from surface.

Inasmuch as the observations upon the shafts extended through a period of five months, and out of this time infiltration was noted during but two months, if only two-fifths of the infiltration found is considered, the amount deduced ought to be unobjectionable.

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At the rate of 0.75 cubic foot per hour per square foot of filtering surface, 2+ summit water-prisms would be supplied every twenty-four hours, or 480+ prisms for the eight months, two-fifths of which is 192 *summit-level water-prisms due to infiltration.*

In deducing the above quantity, infiltration is considered as taking place only from surface above water-line of canal.

The amount available yearly for the use of the canal can be thus stated:

	Summit-prisms.
Yearly supply from rains that can be made available	368.96
Supply from infiltration	192.00
Total	560.96
The total requirements of canal were found to be, yearly	119.56
Excess of supply beyond requirements, yearly	441.40

The amount available for one year is as follows:

	Summit-prisms.
On hand in lakes, &c	225.00
Yearly available supply from rains	368.96
Supply from infiltration	192.00
Total	785.96
Yearly demand	119.56
Excess for one year	666.40

With a view of embracing, practically, the entire subject as far as connected with the present lines of survey, the requirements of a canal 12 feet in depth are given and compared with the supply of water at command. The depth of 12 feet is assumed, for the reason that if Tampa is taken for one terminus, and the river Saint John's used, 12 feet is the utmost capacity of that river up to the mouth of the Ocklawaha. If any point on the coast north of Tampa is taken for the terminus, then the harbors themselves, by their bars, present 12 feet as a limit.

The main expenditures of water result from lockage and leakage at lock-gates. Filtration will not be considered, but an excess of infiltration taken as a positive supply.

I propose to consider the locks as having the same length and width as those on the Saint Lawrence Canal, viz: 200 feet from miter to miter, width of 45 feet in the clear, with a lift of 8 feet.

Applying the numbers heretofore found, and keeping the same unit of measure—that is, summit-prism, with first dimensions given—the annual requirements will be—

For leakage at lock-gates	7.70	prisms.
For lockage, about	668.00	"
For evaporation	3.00	"
Requirements	678.70	"

Amount due to infiltration	192.00	prisms.
Yearly supply from rain	368.96	"
Total yearly supply	560.96	summit-prisms.
	678.70	
Deficiency	117.74	

It will be observed that the great expenditure appearing in the calculation is from *lockage.* The deficiency of 117.74 prisms may be avoided in two ways:

1st. By the construction of double locks.

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2d. By decreasing the lift of the single locks from 8 to 6 feet. The calculations showing this can be readily followed out from data given, and are not inserted.

Of the two methods proposed above, that of double locks would be preferable; for while economizing water similar to the decrease of lift, in case of crowded business on the canal, it would double the facilities for passing from one level to another.

In view of the above, it is considered that a supply adequate to a canal having a depth of 12 feet and locks of the supposed dimensions has been shown.

CONNECTION WITH THE GULF.

In determining upon the proper terminus for the canal at Tampa, the bay was approached by two different lines, as suggested in your instructions; one terminating at the deep water of the river Manitee, the second at the deep water of Hillsboro Bay.

LINE TO THE MANITEE.

This line separates from the one to Hillsboro Bay at a creek known as "Fox Branch," and does not vary in the generally favorable character of the country passsd over until it touches the streams flowing north into Tampa Bay, viz: the Alafiá, Bullfrog, Little and Great Manitee Rivers.

These streams are in general parallel with each other, and crossed by the line nearly at right angles; hence, after getting abreast of the head of Hillsboro Bay, the profile of the line presents a succession of swells and depressions throughout its remaining length; the swells forming the divides of the streams mentioned, and the depressions the valleys of the streams themselves. This feature of the line is unfavorable, for it involves two important facts in the actual construction of the canal: 1st. Aqueducts and embankments to cross each stream; 2d. Considerable excavation to pass the ridges dividing the streams. After reaching the Great Manitee, the following objection is still encountered: The depth of water over the bar at its mouth is only 9 feet, less than might be required by vessels which would enter the bay; and there is no protected anchorage near except in the river. In general, by terminating at the Great Manitee, the canal would be increased in length, the cost of construction greater, and communication with the Gulf less perfect and more exposed than the character of the bay requires.

LINE TO THE HILLSBORO.

From Fox Branch this line continues in a direct course for the valley of the Hillsboro, which, when struck, is followed to a point near Higler's Bridge, where it is proposed the river itself shall be entered and made use of to near its mouth.

To make the connection between the bay and canal as perfect and rapid as practicable, the latter should evidently terminate at some point susceptible of being reached by all vessels trading in the bay, affording secure anchorage, also where the required depth of water approaches near shore. This point is indicated by the natural anchorage of the bay near "Ballast Point," 3½ miles from the mouth of the Hillsboro, and has been selected as more nearly than any other fulfilling the desired conditions.

The manner of uniting with the bay is more particularly as follows:

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The canal is designed to enter the Hillsboro about 4 miles above the town of Tampa, and the river is then used as far as the mouth. Starting just inside the bar, the canal leaves the river, following the low ground near the shore until it debouches into the bay at the anchorage near "Ballast Point." Between the mouth of the Hillsboro and Ballast Point it is proposed that the canal shall be of sufficient depth and width to allow of all vessels ascending to the town of Tampa and meeting the boats in the river, instead of the boats proceeding to them in the bay, a position at times somewhat exposed.

The advantage of this is considered of a twofold nature: 1st, it presents an extensive water-front for trade, and a harbor in which communication between sea-going vessels and those trading on the canal will always continue uninterrupted; 2d, it will in point of fact place the wharves of Tampa upon the deep water of the bay, and thus be of very important advantage to the town itself. This work, it is conceived, presents no obstacle in construction, as two locks each, with double gates—one at the point where the canal leaves the river, the other where it enters the bay—would enable vessels to pass in and out under all possible circumstances of tide, &c.

The objection to communicating with the ship-anchorage through the mouth of the river and by the bay is deemed to be twofold: first, the required depth of 6 feet could not be taken over the bar of the river with any certainty except at high tide; second, during the prevalence of storms transit boats probably would not be able to descend to the anchorage at all; hence the communication between canal and bay would always be imperfect, and at times wholly interrupted.

The line of canal found practicable and recommended as proper to connect the head of navigation of the Saint John's with Tampa Bay is as follows: Starting from the Saint John's at the mouth of Weekivah Creek, the valley of this stream is followed up until near its head, then as direct a course as the nature of the ground will admit of is taken to the low depression of sand-hills which form the crest of the summit divide of the interior; from thence the course is direct for the valley of the Hillsboro, which is followed until the depth of water in the river is sufficient and its course direct enough to render it proper for the canal to enter it. This point is decided to be near Higler's Bridge, some 6 miles from Fort Brooke. Leaving the river as it enters the head of the bay, the western shore of the bay is followed to the terminus near Ballast Point.

ESTIMATE OF COST OF CONSTRUCTION.

In making out the estimate of the cost of a work, the location of which is not absolutely fixed, the profiles, plans, and details of construction essential to a minute statement of items making up the cost are necessarily wanting.

The case under consideration is such a one; the survey has shown the practicability of a canal across the peninsula, and pointed out the line along which it should run to connect the points indicated in the instructions; but the exact cost of labor, of materials, of foundations for locks, hence of the locks themselves, &c., cannot be stated except in general terms, until the works are actually planned upon the ground and ready to be commenced.

In the amounts which follow, prices are fixed which in similar works

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correspond to known cost, due allowance being made for a perfect and durable style of finish.

The nature of the entire work is simple, being, with two exceptions, excavation and embankment, having locks at rather regular intervals, usually single and never more than a flight of two, separating adjoining levels.

The exceptions mentioned are at the crossings of Reedy and Hitchapocasassa Creeks. At the first, the bottom of the canal passes 5 feet above the ordinary water-line of the creek, and an aqueduct crossing it should leave a water-way to the stream of 50 feet in width; the embankment approaching and leaving it will have a total length of 500 yards, and an average height of 12 feet. As the reach passing this stream is a long one, it is desirable that works should be constructed for making the stream a feeder to the canal. A dam thrown across it a short distance above the point of crossing, with gates for retaining or drawing off the water and a feeder leading to the canal, will, together with the aqueduct and embankment, comprise the exceptional works indicated at Reedy Creek.

At Hitchapocasassa it is not thought necessary to turn the water into the canal, the bottom line of which passes 7 feet above the ordinary surface of the stream; a water-way of 75 feet in width should be given to the stream.

EXCAVATION AND EMBANKMENT.

The calculation for this is made on the supposition that one man can dig and throw into a wheelbarrow or cart 15 cubic yards in a working day of ten hours; that another man can wheel on a level the same amount during the same time a distance of 40 yards; when the distance exceeds 40 yards the price must be increased in proportion; that a horse and cart can transport a like amount a distance of 1,000 feet in ten hours, or half the amount a distance of 2,000 feet in the same time up an ascent of 1 in 20.

The labor of a man is taken at $30 per month; cost of boarding him at $6 per month. The labor of a horse and cart is valued at $1 per day.

There are six days to be deducted from the month, four Sundays and two rainy days, as lost time.

The 24 working days of a month will cost for a man $36, and for a horse, cart, and driver, $66. Taking the total amount of excavation along line of canal and arranging it according to cost per cubic yard of digging and hauling, we have the following:

Excavation of 1,445,314 cubic yards common earth, at 42 cents	$607,031 88
Excavation of 1,031,968 cubic yards common earth, at 26 cents	268,311 68
Excavation of 669,141 cubic yards common earth, at 22 cents	157,211 02
Excavation of 5,510,761 cubic yards common earth, at 18 cents	991,936 98
Excavation of 2,086,764 cubic yards common earth, at 16 cents	383,382 24
Excavation of 1,135,200 cubic yards common earth, at 14 cents	158,928 00
Total for excavation	2,567,301 80

LOCKS.

The total elevation to be overcome in passing from the headwaters of the Saint John's to the summit-level of the canal as established, is 197 feet, measured from the surface of the water in each. From Hillsborough River to summit-level, the elevation to be overcome is 119 feet; the locks are supposed to have a lift of 8 feet; this will give 14 between Saint John's and summit, (the surplus (4 feet) occurring at Saint John's to

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allow for lowest stage of the river,) and 15 between the summit and Hillsborough River. Adding the two necessary at the bay—one where the canal leaves the river near its mouth, the other where it terminates at Ballast Point—we find the total number of locks required by the work to be *thirty-one.*

In estimating the cost of one lock, the bottom and side-walls of the chamber, head and tail bays, are supposed to be faced with granite brought from northern quarries; other materials from the vicinity, distance not exceeding 10 miles; dimensions, as given in instructions, 110 by 16 feet in the clear. The calculation makes the cost between $24,000 and $25,000; the last amount is taken.

Thirty-one locks, at $25,000	$775,000 00
Aqueduct, dam, waste-weir, and gates, at the crossing of Reedy Creek	35,000 00
Aqueduct at crossing of Hitchapocasassa—stone quarried on the spot	20,000 00

WASTE-WEIRS.

The number and size of these will be regulated by the number of small streams intersected by and received into the canal, and should be equal to keeping up as rapid a drainage of country, during periods of unusual rains, as now exists by means of the streams themselves. The number required along the entire line will be about 35, and need not vary materially in size; the average quantity of masonry in each would be about—

45 cubic yards, which at $14 per cubic yard	$630 00
35 waste-weirs, at $630, say	22,050 00

FEEDER.

Until a more extensive survey has been made, the precise length in yards of feeders required cannot be given. In speaking of the quantity of water that could be supplied to the summit-level, it was stated that *seven* miles of cutting would connect the entire series of lakes and swamps to be made use of. Not to underestimate, the total length of cutting for feeders will be estimated at 10 miles.

The feeder is supposed to be 28 feet wide at bottom and 6 feet deep

Excavation of 469,211 cubic yards of earth, at 16 cents	$75,073 60
Clearing ten miles, at $500	5,000 00
Ten gates for regulating supply, at $1,000	10,000 00
Total for feeders	90,073 60

GRUBBING AND CLEARING OF MAIN LINE.

In consequence of the numerous small cypress-swamps cut through by the line, the expense of this will be higher than if the country was more open.

Grubbing and clearing 107.33 miles, at $300	$32,199 00

RETAINING-WALLS.

In consequence of the sandy nature of the soil where the line of canal cuts the dividing-ridge near Hawk Creek, and the depth of the cutting required to pass it, it is believed the sides of the canal will need an artificial support to resist the tendency to fill in arising from infiltration; the total distance requiring such support has been estimated at 2,867 yards.

There were no indications of rock found nearer to this point than 12 miles on the Withlacooche, in a northwest direction. Assuming that the stone requires transportation for this distance, the cost of revetment or supporting-walls per linear yard will be about $18; the 2,867 yards, at $18, will amount to $51,606.

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The expense of these walls would be saved in part, from the fact that being vertical, or nearly so, the cross-section of the open cut would be much diminished, hence the estimate for excavation lessened; but in consideration of there necessarily arising many contingent expenses in the execution of a work which cannot appear in an original estimate, it is preferred that the above amount stand as an additional item and disconnected from others.

CLEARING AND PREPARING BANKS OF HILLSBOROUGH RIVER.

To prepare this river to serve as a continuation of the canal, it will be necessary to clear, smooth, and level the banks, in some places fill in and flag, in others cut away, in order to prepare a tow-path; in general, however, the banks will require comparatively little work, and it is estimated that $4,000 per mile will be sufficient.

7½ miles, at $4,000	$30,500 00

No item is inserted for ramming and dressing embankments, as it is considered far better to transport over it, and this can usually be done.

SUMMARY OF ESTIMATE.

Excavation and embankment	$2,567,301 80
Locks	775,000 00
Aqueducts	55,000 00
Waste-weirs	22,050 00
Feeders	90,073 00
Retaining-walls	51,606 00
Clearing and grubbing	32,199 00
Hillsborough River	30,500 00
Total	3,623,729 80
Add 2 per cent. for wear and breakage of tools	72,474 58
Grand total	3,695,204 38

The line across the peninsula is naturally divided into four divisions, as follows: Starting from the Saint John's, division No. 1 extends to the last of the series of locks necessary to ascend the valley of the Weekivah.

Division No. 2 consists of the long level stretching from Lake Weekivah, and terminates at the summit-level.

Division No. 3 is summit-level.

Division No. 4, the line between summit-level and Tampa Bay.

The cost of construction will be distributed according to estimate, as follows:

Division No. 1, 17 miles, 880 yards in length, and 10 locks	$513,205 70
Division No. 2, 28 miles, 1,053 yards in length, and 4 locks	504,703 36
Division No. 3, 21 miles, 473 yards in length	1,671,294 96
Division No. 4, 46 miles, 1,707 yards in length, and 17 locks	994,208 34

Having embodied the results of the survey connected with the line in the foregoing remarks and estimates, I will refer briefly to a line run to the Ocklawaha River, and connecting with the one to Tampa.

A line of canal across Florida, to be most valuable to commerce, evidently should take as direct a course from the Atlantic to the Gulf as practicable. To ascend the Saint John's to near its headwaters, and then cross to Tampa, is undoubtedly circuitous as a line of communication to avoid the straits of Florida, and the depth of water in the upper Saint John's is such as limits navigation to boats of light draught. It would, unquestionably, be better to connect the canal with the lower

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portion of the river, at some point to which the depth of water carried over its bar can be brought; more especially so if distance, at the same time, is saved. With the above in view, also, agreeably to your instruction directing any lines to be examined that might be deemed favorable, the survey was carried from a point of the first line known on the map as Fox Branch, to the headwaters of the Ocklawaha River.

Supposing the canal to reach the Saint John's from Tampa, by continuing down the valley of the Ocklawaha, this route may be compared with the first, in a few words, as follows:

The summit-level will be 18 feet lower; it has the same sources of supply, and numerous lakes near the headwaters of the Withlacoochee additional.

The length of the canal to be constructed will be increased some 50 miles, and the transit across the peninsula shortened by about 20 miles.

The expense of construction will be less in proportion to distance, since the sand-ridge cut by the summit-level of the first line is in this not met with. The fact of avoiding the sand-ridge, also being able to establish the summit-level lower, will decrease the estimate for construction about $750,000 for an equal number of miles. This will make the entire cost of the Ocklawaha route about $400,000 more than the first line, dimensions of the two being the same.

Taking up the data for supply of water already used, it can be easily shown that there is an abundance for a canal having a depth of 12 feet, and it is with a view to such a depth being desirable for the canal that the Ocklawaha route becomes of interest; its junction with the Saint John's would be near Pilatka, up to which point 10 to 11 feet can be carried. That such a depth is essential to the undertaking of the work as a national object, seems pretty evident, for without it there would be two extra transshipments, together with time, labor, and consequent expense attending it. But, could vessels carrying on the coasting trade have a channel leading to the Gulf presented to them absolutely free from the dangers incident to the navigation through the Straits of Florida, entailing no expense incident to a double handling of cargo, and by means of which the time of their arrival in the Gulf could be calculated with certainty, this time, too, being less than a voyage around Florida requires, it is believed that then, and only then, the elements of a successful line of water-transit are shown.

If the river Saint John's had the requisite depth up to the mouth of the Weekivah, then would the first be a more favorable line than the second, as regards original cost of construction; there is water enough to supply the summit-level on either line, should the canal have a depth of 12 feet.

The points of the river presenting the shoal water are as follows: Near the mouth of the Ocklawaha the depth shoals to 10 feet; the outlet of Lake George has only 9 feet, and this general depth continues for some 3 miles. The inlet of Lake George has on its bar, ordinarily, 6½ feet; rains will increase and wind may lessen this depth; beyond this, the river has a depth varying from 15 to 20 feet, up to Lake Monroe; outlet of Lake Monroe, scant 5 feet. The bars at the entrances to the different lakes are permanent obstacles, unless constantly being improved; the expense attending such improvement would, doubtless, make the Ocklawaha much the cheaper route in the end, and the line in this case would pass near to and through a much more fertile and important part of the State than if starting from the mouth of the Weekivah.

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The conclusion in reference to the two routes is this: If a depth of only 6 feet is given to the canal, then the first line is preferable; if the entire depth of water available in the Lower Saint John's is desirable to be carried across the peninsula, then the second or Ocklawaha route is preferable. It has already been stated that both are practicable, and can have a full supply of water.

I take occasion to remark, in this connection, that the map shows a rather favorable line, starting from the harbor of Crystal River, and striking the Saint John's at the mouth of the Ocklawaha. How favorable the ridge dividing the Withlacoochee and Ocklawaha Rivers may be for crossing is not known; but, before deciding upon any line as the best for crossing the peninsula, this one should be examined; want of funds prevented this being done by myself.

* * * * * * *

The main objections to the work are the two following:

1st. The line of transit embraced in present surveys is too circuitous.

2d. The depth of water (limited by the Saint John's and by the harbors on the western coast to 11 and 12 feet) is not as great as is desirable for an important ship-canal.

The Saint John's above its bar could be deepened; but, in that event, the terminus on the eastern side (canal having a greater depth than mentioned) would be the mouth of the Saint Mary's, and would involve the necessity of deepening the inland passage between the Saint John's and Saint Mary's.

Saint Mary's, or Fernandina Harbor, is the natural terminus for any canal connecting the Atlantic and Gulf, for it is the last port on the Atlantic coast capable of admitting vessels drawing more than about ten feet; hence the only point where trade would center on its way eastward, and be met by vessels for distribution to home and foreign markets.

In concluding this report, the attention of the Colonel of Topographical Engineers is respectfully called to the subject of the practicability of a ship-canal across Florida as it now rests. There are at least four lines across the peninsula which should be surveyed before any one can be decided upon as preferable to the others; two of these lines only have been run, and either one of the two remaining, if found favorable, would be preferred to those reported upon; for, in the first place, being nearer the base of the peninsula, there would be less deviation from the general line of the Atlantic and Gulf coast—hence a decrease of the length of water-communication from south to north; next, the line of canal would be more direct, and would run across Florida at about its narrowest point.

In view of the above, it is respectfully urged that an additional appropriation for continuing the Florida Canal survey be recommended, in order that the subject may be fully and completely discussed, and leave no unexamined points for future doubt.

It is believed that $15,000 might, if economically used, enable all desirable information to be obtained; $20,000 is, however, considered a much safer amount to estimate for, and is the sum named and respectfully urged to be recommended by you.

I am, very respectfully, sir, your obedient servant,

M. L. SMITH,
First Lieutenant Topographical Engineers.

Colonel J. J. ABERT.

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APPENDIX J.

ANNUAL REPORT OF CAPTAIN C. W. HOWELL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., September 30, 1876.

GENERAL: I have the honor to transmit herewith the annual reports, for the fiscal year ending June 30, 1876, of the various works of river and harbor improvements under my charge.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

J 1.

IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER AT SOUTH-WEST PASS.

The work was conducted throughout the year in the same manner as during previous years.

Even with the relatively increased volume of discharge through South-west Pass, which has marked the year, and the positive increase in velocity of current, suggesting scour of banks and bottom of the body of the pass, with increased amount of deposit on its bar, the dredges have been able to maintain a more uniform depth and width of channel over the bar than has been reported for any previous year.

While this channel has not been deep enough to allow the largest sea-going vessels trading with New Orleans to load to their maximum draught, it has yet, by careful management and by the generally considered action of those interested, been made to meet the necessities of this commerce better than heretofore. For many years past there have been notable blockades and detentions, resulting in great losses to the vessels detained.

During the past year there has been no blockade such as heretofore, and no very serious detention, except that of the steamship Alabama, of 360 hours, caused by her loading to the excessive draught of 20 feet 4 inches.

As a portion of the history of the work, a tabular statement is appended, of which the following is a synopsis:

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Table of dredging and its results.

Month.	Number of hours dredging on bar.		River falling, (−); river rising, (+); river at stand, (0).			Number of days the channel had a depth at mean low tide, as indicated below.									Tides ranging above mean low, in feet.	Number of vessels using channel.	Greatest draught of same, in feet.	Number of vessels detained.	Number of hours' detention of vessels on bar, arranged according to draught of vessels detained.										
						Feet.													Feet.										
						17.	16½.	16.	15½.	15.	14½.	14. *	13*‖	12. *					20½.	19½.	19.	18½.	18.	17½.	17.	16½.	16.	15½.	15.	Less.
	h.	m.																										
July	122		+	−	&	+	....	11	16	4	....	....	....	....	....	*2½ to 3	92	19.6	10	360	2.	.....	10.40	.....	13.	9.	20.	80.45	....	....	.....
August†	233	55	−	+		+	1	6	2	2	....	¼	§5	§2	§4	*2½ to 3 ¶1½ to 2½	54	18.4	3	....	....	.....	74.15	13.	.....	.....	24.15	.....	....	....	.....
September	102	10		+	+	−	16	14	....	....	....	....	....	....	....	1½ to 3	58	19.6	1	....	....	.....	.....	.....	.....	24.30	.....	.....	....	....	.....
October	58		−	+	+	−	....	8	23	....	....	....	....	....	....	2 to 2½	129	19.3	8	....	....	99.	46.30	.....	.....	.....	5.	7.	....	....	.....
November	15	55	+	−	&	+	....	11	19	....	....	....	....	....	....	1½ to 2½	169	19.6	5	....	....	.....	97.	.....	.....	18.	....	.....	....	....	.....
December	18	45	+	−	&	+	....	3	28	....	....	....	....	....	....	1½ to 2½	262	19.6	8	....	6.	30.	34.	.....	.....	94.	.....	.....	....	....	6.
January	58	35	−	+	−	+	....	....	25	6	....	....	....	....	....	2 to 3	294	19.6	12	....	5.	2.30	2.	143.	8.	8.	.....	.....	....	....	12.
February	112	40	+	−	−	+	....	....	6	19	4	...	....	....	....	2 to 2½	290	19.	29	....	.....	22.35	78.65	4.55	.....	174.10	1.45	36.30	4.35	58.	36.55
March	143	20	−	+	&	−	....	....	16	10	5	....	....	....	....	2 to 2½	251	19.4	19	....	28.15	83.40	1.30	178.45	2.10	.....	.....	4.20	....	9.45	41.05
April	81	50	+	+	&	+	....	....	30	....	....	....	....	....	....	2 to 2½	186	18.9	16	....	.....	.....	24.45	51.10	63.	48.25	.....	.....	....	....	.....
May	62	35		−	0	−	....	....	12	17	....	2	....	....	....	2 to 2½	163	19.	11	....	.....	2.50	62.40	17.	119.40	24.	.20	19.45	....	....	2.
June	74	10			+		....	....	18	12	....	....	....	....	....	2½ to 2½	81	19.	6	....	.....	22.	48.15	158.	.....	.....	.....	.....	....	....	4.
Total	1,083	55	..	....	..	17	53	195	70	9	6	5	7	4	.....	2,029	.....	128	360	41.15	262.35	410.40	565.50	205.50	472.05	91.20	148.20	4.35	67.45	102.

* Guage for these depths reads *extreme* low tide.
† The figures in this statement, up to and including August 15, 1875, refer to work done at Pass à l'Outre. After that date they refer to work done at Southwest Pass.
‡ Depth of channel at Southwest Pass.
§ Depth of channel at Pass à l'Outre.
‖ The report of 13 feet at Southwest Pass was the depth of channel before dredging commenced.
¶ Gauge readings changed to *mean* low tide.

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THE ESSAYONS.

Late in December last, it having been definitely ascertained that for many months to come commerce would be dependent on a Southwest Pass channel, the Essayons was placed in dock for the general repair contemplated by the act of Congress appropriating $100,000 for that purpose.

With all the delay incident to such work I was able to dispatch the dredge-boat as good as new to Southwest Pass on the 12th of June, at which time it was necessary to make comparatively slight but important repair to the McAlester.

The repairs to the Essayons were of the most general and thorough description. They were estimated before commencing them, with as great care as possible, at $90,000. The total cost has been somewhat greater. For the repair of hull it was found necessary to remove nearly one-half of the top futtocks and top timbers of the frame, which was found badly decayed above the light-draught line. The timbers to replace these are of clear heart cypress. The planking stripped off to take out decayed timbers and put in new, was also replaced by cypress water-seasoned. Stem and stern posts were put in new; a piece was scarfed on after end of keel, which was so wormed as not to properly hold the after shoe. This shoe was given two additional straps. Numerous pieces of wormed planking near the keel, where the copper had been rubbed off, were replaced. The vessel was entirely stripped of copper, and this replaced by heavy composition. The ceiling of the hull, necessarily removed to repair frames, was renewed. The upper deck was in bad condition, especially over the boilers, and was partly renewed and the remainder repaired. The deck-houses were all repaired and the whole vessel newly painted. The forward shoe, plow, and rudder were nearly worn out by scouring, and were repaired by welding on new pieces and partly replacing the rudder covering. A new deflector tram-way was put on, the old one being badly brushed up and further injured in taking it off. The deflector had been badly jammed, twisting its arms, bending tie-rods and buckling-bands and plates. This was thoroughly repaired. The propeller-shafts were recased and their sleeves relined; the sockets in hub of excavator had worn so much as to give the blades considerable play. These were trued up and new blades cast to fit them.

MACHINERY.

New cylinders were made for deflector hoisting-engines of larger diameter than the old ones to take steam at low pressure from the main boilers and facilitate handling of the deflector. The hoister admidships, which was quite worn out, was repaired.

Piston-heads of main engines were trued up and repacked; piston-rods trued. The valve-gear, which was much worn, fully repaired. The eccentrics trued and new eccentric-straps made. New tubes and packing were put in condensers. The circulating pumps repaired and additional thrust-bearing given them. Air, feed, and bilge-pumps were repaired, and all injection, delivery, and connecting-valves overhauled and ground in.

BOILERS.

The boilers were in very bad condition, much worse than could have been ascertained before moving them for repair. The water-bottoms

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were nearly gone and had to be entirely cut off. They were replaced by water-legs and cast-iron ash-pans resting on a thick cement flooring. A large number of sheets, particularly on the backs and tops of the boilers, were in very bad condition, due in part to the impossibility, for lack of space, of getting at them to scale and paint. All weak sheets were removed and new iron put in. All tubes were taken out and new ones put in. The boilers were covered with new felting and sheet-lead. A new smoke-stack was provided, the old one having rusted through in many places so as to make it very weak. All steam-pipes and other connections were necessarily torn up, and required much labor for their replacement.

On completion of repair the boiler was tested to 60 pounds cold pressure with very satisfactory result. When steam was first given the engines, but four leaks were found in connections, although these have some 1,600 joints. At the first test of engines not hooked on, they were found to work perfectly—as well, if not better than ever before. When hooked on at the wharf they worked equally well, and without the usual precaution of a trial-trip the vessel steamed down the river and re-commenced her work on the bar, where, without trouble from her machinery, she has since been working. I mention this that due praise may be given Mr. P. B. Sexton, the chief steam-engineer of the dredge-boats, under whose untiring superintendence such an exceptional result has been obtained. Equal credit is due to Captain C. H. Elwell, senior master of the dredge-boats, for the fidelity and excellent judgment with which he superintended the repair of hull. Both of these gentlemen have been connected with the work at the mouth of the river since its commencement in 1868.

The work of repair was conducted as follows:

Dockage and demurrage in the Louisiana dry-dock was contracted for at the same prices as heretofore paid the Marine dry-dock. The Dock Company furnished timber, oakum, bolts, spikes, &c., and labor, at prices verbally agreed upon beforehand, and considerably lower than the card-rates. Bids were received for sheathing-metal, and contract given to the lowest bidder. Bids for boiler-work were received, and contract given to the lowest bidder, who was furnished his iron, which was also purchased of the lowest bidder. Felting and sheet-lead were procured in the same way. Boiler and condenser tubes and packings were purchased from the manufacturer in New York. The shop-work on engines and machinery was done, as heretofore, by day's work, and at fixed prices for material. The mechanical work on board ship, except for boilers and plumbing, was done by hired labor, under the direction of the steam-engineers before employed on the vessel. A time-keeper on the ship and one in the shop kept a full account of labor and material and reported weekly.

THE MCALESTER.

Owing to delay in getting the Essayons ready, the McAlester was worked, without repair of her shaft casing and sleeves, longer than usual. When the Essayons was ready to relieve her, she was, therefore, immediately brought to the city, placed in the end dock, and her shaft and sleeves, with plow, shoe, and rudder, which had been broken loose while at work, were sent to the shop. A section of her mud-keel had also been carried away, and iron to repair it was sent for. Two piston-heads of main engines, which required truing, were also sent to the shop. Her condenser-tubes are being replaced by those taken from the Essayons, which I have had retinned for the purpose. Some soft

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patches have been put on main boilers. Completion of work is only delayed by trouble in getting iron plates of the dimensions required for mud-keel, manufacturers declining to make special size, as only two sheets are required. Repair will soon be completed.

THE END DOCK.

This is in good condition and has done excellent service. Up to the end of the fiscal year her net saving to the work has been $39,431 plus her present value. I consider her as good as new.

THE COAL-BARGE.

This vessel has been employed throughout the year as tender to the dredge engaged on the bar. She is getting old and very weak, and has been loaded accordingly, making it necessary to send her more frequently to the city for coal.

THE STEAM-LAUNCH.

This has been employed almost continuously throughout the year on surveys. When not otherwise called for, she has been used by the inspector of the South Pass jetty work in prosecuting surveys at that pass. She is in very good condition.

SURVEYS.

These were continued at intervals until late in April. The work has all been plotted, and reports of assistants will be completed shortly, after Lieutenant Davis can be for a time spared from active personal superintendence of the work at Galveston.

Copies of the most important plots and tables have been from time to time forwarded to the Chief of Engineers, U. S. A.

It is desirable to rerun some of the deep-sea lines as soon as the river is at low-water stage, as further verification of the facts shown by previous soundings.

The steam-launch, and at times the reserve dredge-boat, have been employed on this duty.

REGULATIONS.

The regulations established by the Hon. Secretary of War for the use of the channels dredged have been very generally observed, and have been of great service in helping to keep the channel clear.

COMMERCIAL STATISTICS.

The following has been received from the collector of the port of New Orleans:

Number of entrances, steam-vessels	386
Number of clearances, steam-vessels	393
Total tonnage of same	884,765
Number of entrances, sailing-vessels	829
Number of clearances, sailing-vessels	841
Total tonnage of same	872,324
Total value of imports, specie, free and dutiable	$11,602,873 00
Total value of exports, domestic, to foreign countries	83,894,196 00
Total value of exports, foreign, to foreign countries	333,974 00
Grand total of exports	84,228,170 00
Amount of revenue collected on imports	1,844,776 94

The work is located in the collection-district of New Orleans, and near the light-house at Southwest Pass.

It is not susceptible of permanent completion, and for its continuation next year will require an appropriation of $150,000.

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PROJECT FOR ENSUING YEAR.

It is proposed to employ one dredge at a time, holding the other in condition in reserve or undergoing repair; to have both boats ready to work on the bar during the critical season, which extends from about half-flood stage of the river to about the middle of the flood season, and is characterized by a hard sand bottom to channel and a rapid extension of bar.

Surveys for channel charts and lump movements, and of outer slopes of bars to 300 feet depths, are also proposed.

It may be necessary to purchase a new coal-barge.

Money statement.

Amount available July 1, 1875	$261,707 59
Amount expended during fiscal year ending June 30, 1876	226,687 40
Amount available July 1, 1876	35,020 19
Amount appropriated by act approved August 14, 1876	100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	150,000 00

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River for the fiscal year ending June 30, 1876.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at Pass à l'Outre. 6 a. m. Direction.	6 a. m. Force.	12 m. Direction.	12 m. Force.	Hours worked by dredge-boat.	Depth of channel at extreme low tide.	Height of high-tide above extreme low-tide.	Total depth of channel at high-tide.	Least width at extreme low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at Pass à l'Outre. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1875.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
July 1	8.4	E.	1	E.	2	8 00	....	....	....	....	2	3	1	19 6	2 00	Ship Hagerstown, 19′ 6″, bound out, grounded at Twin Cans at 6 a. m.; got off at 8 a. m. and went to sea.
													1		20 00	Bark Charles E. Jayne, 16′ 6″, bound out, grounded above Can 4 at 10 a.m.
2	8.1	N. E.	1	N. E.	2	9 00	....	....	....	....	1	4	....	19 0	.....	Bark Charles E. Jayne went to sea this a. m.
3	8.0	N. E.	1	E.	2	8 00	16	3	19	50	2	1	1	16 0	15	Steamer Haytien, 16′, bound out, grounded near Can 4; went to sea same day.
4	7.9	S.	1	S. E.	1	.....	....	....	....	....	1	6	....	17 0	.....	Slack current.
5	7.9	S. E.	3	S. E.	4	.....	....	....	....	....	1	2	....	15 0	.....	Do.
6	8.0	E.	4	E.	3	.....	....	....	....	....	....	2	1	12 0	10 40	Steamer State of Alabama, 18′ 6″, bound in, at 11 a. m. grounded at Can 4.
7	8.1	E.	3	E.	4	.....	....	....	....	....	1	2	....	18 6	.....	Steamer State of Alabama, got off at 9.40 a. m. and went to city.
8	8.1	E.	1	E.	2	10 00	16	2½	18½	90	....	....	....	.....	.....	
9	8.0	E.	1	E.	3	.....	....	....	....	....	1	3	....	16 0	.....	Slack current.
10	7.9	S. E.	3	S. E.	2	6 00	16½	2½	19	70	....	1	....	12 0	.....	Do.
11	7.9	S.	1	S. E.	2	.....	....	....	....	....	1	4	....	15 8	.....	
12	7.8	S. E.	1	S.	2	11 00	....	....	....	....	1	1	....	18 6	.....	
13	7.7	S. E.	1	S. E.	2	10 00	....	....	....	....	1	2	....	12 0	.....	
14	7.8	S. E.	1	S. W.	3	5 00	16	2½	18½	100	1	1	....	13 0	.....	
15	7.5	N. W.	2	S. W.	1	9 00	....	....	....	....	....	....	....	.....	.....	
16	7.5	S. W.	3	W.	1	8 00	....	....	....	....	1	3	....	18 6	.....	
17	7.3	N. E.	5	W.	2	.....	16	2½	18½	100	2	1	1	16 0	13 00	Steamer Warrior, 17′ 9″, bound out, at 10 a. m. grounded above Can 4.
													1		10 00	Ship Nueva Aurelia, 16′, bound out, at 9.30 a. m. grounded near Twin Cans.
													1		10 30	Steamer New Orleans, 16′, bound in, at 10.30 a. m. grounded near Twin Cans.
18	7.3	W.	2	S. W.	4	3 00	....	....	....	....	1	3	....	17 9	.....	Steamer New Orleans got off at 9 a. m. and went to city; steamer Warrior got off at 11.30 a. m. and went to sea; Ship Nueva Aurelia got off at 7.30 a. m. and went to sea.

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	19	7.4	S. W.	4	S. W.	3	1 00	....	....	....	....	1	2	....	18 0	.....	
	20	7.4	S.	2	S. W.	2	.....	....	....	....	....	1	....	....	18 0	.....	
	21	7.4	S.	1	S.	1	.....	16½	2½	19	60	1	2	....	14 0	.....	Cross-current on bar.
	22	7.3	W.	1	S. W.	1	.....	....	....	....	....	1	3	....	13 0	.....	
	23	7.3	S.	1	S. W.	2	.....	....	....	....	....	....	....	....	.....	.....	
	24	7.3	S.	1	N. W.	4	4 00	16½	2½	18¾	100	6	....	1	18 0	60 00	Bark Carmela, 16′, bound in, grounded above Twin Buoys, north of channel.
	25	7.2	W.	4	S. W.	4	.....	....	....	....	....	2	....	....	8 0	.....	
	26	7.1	S.	3	S. W.	3	.....	....	....	....	....	....	3	....	17 0	.....	
	27	7.0	S. E.	1	S.	1	7 00	....	....	....	....	4	....	....	16 0	.....	Bark Carmela got off and went to city.
	28	6.9	S. W.	1	S.	1	11 00	15½	2½	18	70	....	1	....	16 0	.....	
	29	6.7	S.	1	S. E.	2	6 00	....	....	....	....	....	2	1	12 0	360 00	Steamer State of Alabama, 20′ 4″, bound out, at 6 a. m. grounded in channel 1,000 feet above upper buoy.
	30	6.4	S. E.	1	S. E.	4	3 00	....	....	....	....	....	3	1	15 6	9 00	Bark Altagracia, 17′, bound out at 10 a. m.; grounded near Can 4.
	31	6.3	S.	3	S. W.	2	3 00	....	....	....	....	2	2	....	17 0	.....	Bark Altagracia got off at 7 a. m. and went to sea.
Aug.	1	6.3	S. W.	4	S. W.	5	6 05	....	....	....	....	....	1	....	6 0	.....	
	2	6.3	S. W.	2	S. W.	1	.....	14	3	17	60	2	1	....	15 6	.....	Work delayed by bad weather.
	3	6.3	S. W.	1	S. W.	3	.....	....	....	....	....	1	....	....	15 6	.....	
	4	6.3	S. E.	1	S.	1	.....	13	2½	15½	50	....	2	....	16 0	.....	Work delayed by grounded vessel.
	5	6.2	S.	1	S. W.	2	.....	....	....	....	....	....	....	....	.....	.....	Do.
	6	6.2	S. W.	3	S. W.	4	.....	....	....	....	....	1	1	....	8 0	.....	Do.
	7	6.1	S. W.	4	W.	5	.....	....	....	....	....	....	....	....	.....	.....	Do.
	8	6.1	S. W.	2	S. W.	2	.....	14	2½	16½	50	1	2	....	16 0	.....	Do.
	9	5.9	S. W.	2	S.	1	7 40	14	2½	16½	50	1	....	....	6 0	.....	
	10	6.2	S.	4	S.	2	8 15	....	....	....	....	....	1	....	6 0	.....	
	11	5.8	S.	1	S. W.	2	3 20	12	3	15	50	....	1	....	8 0	.....	Squally weather.
	12	5.8	S. W.	3	S. W.	2	.....	....	....	....	....	....	....	....	.....	.....	
	13	5.7	S. W.	3	S.	1	E. 14 00 M. 10 00	12	3	15	80	....	....	....	.....	.....	Steamer State of Alabama pulled back inside of bar at 6.30 a. m., after being lightened to 17′ 11″.
	14	5.5	S. W.	3	W.	4	5 00	....	....	....	....	1	1	....	17 0	.....	
	15	5.3	S. W.	4	S. W.	2	12 00	13	3	16	70	1	2	....	15 0	.....	Stopped work at Pass à l'Outre to go to Southwest Pass.
	16	5.2	W.*	4*	W.*	5*	10 00	12†	1. 2†	13. 2	200†	....	....	....	.....	.....	Dredge-boat McAlester left Pass à l'Outre, Louisiana, at 12.45 a. m., for Southwest Pass, where she arrived at 5.15 a. m.
	17	5.2	N. W.	3	S. W.	1	10 00	12	1. 2	13. 2	200	1	1	....	13 0	.....	Too rough for soundings.
	18	5.1	W.	4	W.	6	4 00	13	1	14	....	....	1	....	16 0	.....	Cross-current; bad weather.
	19	5.3	W.	1	W.	3	14 00	14½	½	15	50	....	....	....	.....	.....	
	20	5.5	W.	1	N. E.	4	8 00	....	....	....	....	1	....	1	7 0	64 15	United States Steamer Canandaigua, 16′ 6″, bound out, at 9.45 a. m. grounded.
	21	5.4	N. E.	3	N. E.	3	.....	....	....	....	....	....	....	....	.....	.....	Too rough for work.
	22	5.4	E.	1	E.	3	19 15	....	....	....	....	....	....	....	.....	.....	
	23	5.5	N. E.	2	E.	1	11 40	15½	1½	17	70	1	1	....	16 6	.....	United States Steamer Canandaigua got off and to sea at 2 a. m.
	24	5.2	E.	3	E.	5	7 05	16	1½	17½	70	1	1	....	15 0	.....	Rough weather.
	25	5.2	E.	3	E.	4	11 00	16½	2	18½	50	....	1	1	8 0	13 00	Steamer State of Alabama, 17′ 11″, bound out, at 4 a. m. grounded on west side of channel.
	26	5.1	S. W.	3	E.	2	10 00	16½	2	18½	50	....	5	....	17 11	.....	Steamer State of Alabama got off and went to sea at 5 a. m.
	27	5.0	E.	4	E.	5	E. 4 40 M. 4 00	16½	2	18½	50	4	2	1	15 6	74 15	Steamer Saint Louis, 18′ 2″, bound out, at 5.30 a. m. grounded on west side of channel.
	28	5.0	N. W.	2	E.	2	E. 7 55 M. 12 00	16	2½	18½	70	4	7	....	18 4	.....	

* S. W. Pass.

† Changed to mean low.

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Wind at S. W. Pass. 6 a. m. Force.	Wind at S. W. Pass. 12 m. Direction.	Wind at S. W. Pass. 12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Casualties at S. W. Pass. Greatest draught.	Casualties at S. W. Pass. Time of delay.	Remarks.
1875.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
Aug. 29	5.0	E.	2	E.	1	15 00	17	2	19	50	....	1	....	16 0	.....	
30	5.0	S. E.	1	S. E.	2	9 00	16½	2½	18½	80	....	2	....	18 4	.....	Steamer Saint Louis, bound out, got off and to sea at 7.45 a. m.
31	5.0	E.	1	E.	1	10 00	16½	2	18½	100	....	....	....	.....	.....	
Sept. 1	5.0	E.	3	E.	2	10 20	16½	2	18½	100	1	2	....	15 6	.....	
2	5.0	E.	1	N. E.	2	11 00	16½	1½	18	100	...	1	....	16 0	.....	
3	5.0	E.	3	E.	4	11 00	16½	1½	18	100	1	3	....	15 0	.....	
4	5.0	E.	1	E.	5	11 00	16½	1½	18	100	....	....	....	.....	.....	
5	5.0	S. E.	1	S. E.	1	11 40	17	1½	18½	40	1	1	....	16 0	.....	
6	5.2	E.	1	W.	1	11 00	17	1½	18½	50	1	....	....	10 0	.....	
7	5.2	N. W.	4	W.	1	12 00	....	....	....	....	....	1	....	15 6	.....	
8	5.4	W.	2	W.	1	7 45	17	2½	19½	50	....	....	....	.....	.....	
9	5.6	E.	1	E.	1	.....	....	....	....	....	1	3	....	13 0	.....	
10	5.8	E.	1	E.	1	.....	....	....	....	....	4	....	....	19 6	.....	
11	6.0	W. SW.	2	W.	3	.....	17	2½	19½	60	....	....	....	.....	.....	
12	6.2	W.	1	N.	2	.....	....	....	....	....	2	2	....	17 6	.....	
13	6.5	N. E.	3	N. E.	4	.....	....	....	....	....	1	....	....	14 0	.....	
14	6.8	N. NE.	4	N.	6	.....	....	....	....	....	2	....	....	17 6	.....	
15	6.9	N. E.	9	E.	5	.....	....	....	....	....	....	1	....	10 0	.....	
16	8.0	S. E.	4	S. E.	4	.....	....	....	....	....	1	....	....	8 6	.....	
17	7.4	S. E.	5	S. SE.	5	.....	....	....	....	....	1	....	....	16 0	.....	
18	8.0	S. SW.	7	S. SW.	6	.....	....	....	....	....	....	....	....	.....	.....	
19	9.0	N. W.	3	N. W.	3	.....	....	....	....	....	1	3	....	17 0	.....	
20	8.9	N.	3	N.	3	.....	....	....	....	....	1	....	....	12 0	.....	
21	9.0	N.	3	N. NE.	3	6 00	16½	3	19½	100	3	3	....	18 3	.....	Ebb tide.
22	9.0	N.	3	N.	3	7 05	16½	3	19½	100	2	....	....	12 0	.....	Ebb tide.
23	8.8	N. NE.	3	N. E.	3	3 20	...	....	....	....	....	3	....	15 0	.....	
24	8.6	E.	4	E.	4	.....	....	....	....	....	1	1	1	16 6	24 30	Bark Leamington, 17′, bound in, at 9 a. m. grounded west of channel below Wreck Buoy.

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	25	8.5	E. SE.	3	E. SE.	3	.....	16½	3	19½	90	3	....	....	17 0	.....	Bark Leamington got off and passed in at 9.30 a. m.
	26	8.0	N. W.	1	N.	3	.....	....	....	....	....	....	1	....	18 3	.....	
	27	8.0	N. NW.	3	W.	2	.....	....	....	....	....	....	....	....	.....	.....	
	28	8.4	W.	2	W.	1	.....	....	....	....	....	2	....	....	14 0	.....	
	29	8.6	N. E.	1	N. NW.	1	.....	16½	2	18½	90	2	....	....	12 0	.....	
	30	8.8	N. NW.	1	E.	1	.....	....	....	....	....	2	....	....	18 3	.....	
Oct.	1	9.0	S. SW.	2	S. SW.	2	.....	....	....	....	....	2	2	....	16 6	.....	
	2	9.0	N. E.	3	N. E.	3	.....	16	2½	18½	90	3	....	....	14 0	.....	Rough on bar.
	3	9.0	E. NE.	1	E. NE.	1	.....	....	....	....	....	2	4	....	19 3	.....	
	4	9.0	N. E.	1	N. E.	1	4 40	....	....	....	....	4	1	....	17 6	.....	
	5	8.0	N. NE.	1	N. E.	1	3 25	....	....	....	....	2	1	....	17 0	.....	
	6	8.9	S. E.	1	S. W.	2	2 00	16½	2	18½	75	2	1	....	15 0	.....	
	7	9.1	W.	1	N.	2	4 50	....	....	....	....	2	2	1	16 0	4 00	Ship Vigilate, 16′, bound in, at 2 p. m. grounded on east side of channel; got off and passed in at 6 p. m.
	8	9.3	N.	2	N.	2	6 35	....	....	....	....	2	2	1	15 6	16 00	Steamer Guillermo, 18′ 6″, bound out, at 7 a. m. grounded on extreme west side of channel; got off at 11 p. m.
	9	9.5	N.	1	N.	1	8 05	16	2½	18½	80	1	2	....	18 6	.....	
	10	9.5	N.	1	N. W.	1	6 30	....	....	....	....	....	3	....	18 4	.....	
	11	10.2	N.	1	W. SW.	1	5 25	....	....	....	....	2	....	....	18 0	.....	
	12	10.7	N.	2	N.	2	.....	....	....	....	....	3	1	....	17 6	.....	
	13	11.1	N.	1	N. W.	2	2 10	16	2	18	80	1	....	....	15 6	.....	
	14	11.7	N.	1	N.	1	.....	....	....	....	....	....	1	....	19 3	.....	
	15	12.0	N. NW.	2	N. NW.	2	.....	....	....	....	....	3	2	....	18 10	.....	
	16	12.5	N.	1	N. W.	1	.....	16½	2½	19	70	1	1	....	14 0	.....	
	17	12.8	N. W.	1	N. NW.	1	.....	....	....	....	....	1	2	....	18 0	.....	
	18	13.0	W.	1	S. W.	1	.....	....	....	....	....	2	....	....	14 0	.....	
	19	13.0	N.	3	N. NE.	2	.....	....	....	....	....	5	6	1	17 6	3 00	Steamer Charles W. Lord, 16′, bound out, at 5 p. m. grounded on bar; got off at 8 p. m.
	20	13.0	N. NE.	2	N. NE.	2	4 00	16	2½	18½	60	5	....	1	16 6	5 00	Schooner John H. Kranz, 16′ 6″, bound in, at 11 a. m. grounded just above Upper Cans; got off and passed in at 4 p. m.
	21	13.0	N. E.	1	N. E.	2	3 20	....	....	....	....	4	1	....	16 6	.....	
	22	12.9	N. NE.	1	N. E.	1	.....	....	....	....	....	5	2	....	16 6	.....	
	23	12.8	N.	1	N.	1	.....	16	2½	18½	60	3	....	....	18 0	.....	
	24	13.1	N. W.	1	W.	1	.....	....	....	....	....	2	5	....	17 9	.....	
	25	13.2	E.	1	E.	1	.....	....	....	....	....	2	1	....	18 0	.....	
	26	13.6	N. E.	1	S. E.	1	.....	....	....	....	....	1	2	....	16 0	.....	
	27	13.6	N. E.	4	N. E.	5	.....	16	2½	18½	60	5	2	....	17 0	.....	
	28	13.7	E.	1	N. E.	3	.....	....	....	....	....	3	3	1 1 1	18 3	1 30 2 00 99 00	Bark Reine des Anges, 16′, bound out, at 3.30 p. m. grounded on west side of channel; got off and went to sea at 5 p. m. Steamer Mississippi, 18′ 3″, bound out, at 4 p. m. grounded on east side of channel; got off and went to sea at 6 p. m. Steamer Palm, 18′ 9″, bound out, at 8p. m. grounded on extreme east side of channel above Can 4.
	29	14.0	E.	2	E.	2	.....	....	....	....	....	5	1	....	15 6	.....	Steamer Palm was pulled inside off bar at 5.30 p. m.; at 6 p. m., in trying again to get out, grounded below Upper Cans.
	30	13.9	S. W.	3	W.	2	3 00	....	....	....	....	2	1	....	15 0	.....	
	31	13.9	N. W.	5	N. W.	5	4 00	16	2½	18¼	70	4	1	16	1 6	28 30	Steamer New Orleans, 18′ 6″, bound out, grounded at Lower Cans at 4.30 p. m.; steamer New Orleans got off bar and went to sea at 9 p. m.
Nov.	1	14.1	N.	2	N.	1	.....	....	....	....	....	2	3	....	18 9	.....	Steamer Palm got off bar and went to sea at 11 p. m.
	2	14.4	S. W.	3	S. E.	1	5 25	....	....	....	....	5	5	1	17 0	18 00	Ship D. W. Chapman, 17′, bound out, at 1 a. m. grounded on west side of channel, near Outer Can; got off and went to sea at 8 p. m.
	3	14.2	S.	3	S. E.	3	3 00	16	2	18	50	4	1	....	14 6	.....	

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Force.	12 m. Direction.	Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1875.	Feet.					h. m.	Ft.	Ft.	Ft.	Ft.				Ft. in.	h. m.	
Nov. 4	13.9	S. E.	4	S. E.	2	3 30	....	....	....	....	8	6	....	18 8	.....	
5	14.0	S. E.	5	S. E.	4	.....	....	....	....	....	5	1	....	18 6	.....	
6	13.7	N.	2	N.	4	.....	16	2	18	50	4	1	....	17 6	.....	
7	13.5	N. E.	5	N. E.	4	.....	....	....	....	....	2	1	....	17 0	.....	
8	13.7	N. W.	5	N. W.	4	.....	....	....	....	....	1	1	....	15 0	.....	
9	13.0	N. E.	6	E.	8	.....	....	....	....	....	2	1	....	19 6	.....	
10	14.0	N. W.	6	N. W.	7	.....	16	1½	17½	50	2	6	....	17 6	.....	
11	14.4	N. W.	2	N. W.	2	.....	....	....	....	....	2	5	....	17 6	.....	
12	14.7	W.	1	E.	2	.....	....	....	....	....	5	2	....	17 0	.....	
13	14.4	S.	2	S. E.	2	.....	16½	2½	18½	60	4	2	....	19 0	.....	
14	14.5	S. E.	4	E.	4	.....	....	....	....	....	2	4	....	18 6	.....	
15	14.7	S. W.	4	E.	5	.....	....	....	....	....	3	....	....	15 0	.....	
16	14.8	E.	1	S. W.	3	.....	....	....	....	....	2	1	....	18 2	.....	
17	14.6	N. W.	6	N. W.	6	4 00	16	2½	18½	60	4	6	....	18 0	.....	
18	14.5	S. E.	2	S. E.	4	.....	....	....	....	....	4	....	....	15 0	.....	
19	14.3	E.	1	S. E.	2	.....	....	....	....	....	2	2	....	18 8	.....	
20	14.3	E.	2	S. E.	3	.....	16	2½	18½	60	5	1	....	17 0	.....	
21	14.1	E.	1	S. E.	1	.....	....	....	....	....	2	3	1	18 6	10 00	Steamer Castilla, 18′ 6″, bound out, grounded on west side of channel, near Can 4, at 5 p. m.
22	13.9	S. E.	3	N. E.	4	.....	....	....	....	....	2	4	1	18 0	7 00	Steamer Castilla got off and went to sea at 3 a. m. Steamer Durham, 18′ 6″, bound out, at 10 a. m. grounded on west side of channel, near Cleopatra Buoy. Steamer Durham got off and went to sea at 5 p. m.
23	13.7	N. E.	4	S. E.	5	.....	....	....	....	....	4	2	....	18 6	.....	
24	13.5	E.	1	N.	5	.....	16½	1½	18	60	1	5	1 1	18 6	3 00 7 00	Steamer Paschal, 18′ 6″, bound out, at 9 a. m. grounded on west side of channel, near last buoy; got off and went to sea at 12 m. Steamer Texas, 18′ 6″, bound out, at 5 p. m. grounded on west side of channel, near last buoy; got off and went to sea at 12 p. m.
25	13.5	N. E.	7	N. E.	4	.....	....	....	....	....	4		....	18 6	.....	

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	26	13.3	S.	2	S.	1						3			17	0		
	27	13.5	E.	1	N.	2		16½	2	18½	60	2			15	0		
	28	13.4	N.E.	2	E.	2						3	7		17	0		
	29	13.0	N.E.	2	N.	2						1			15	0		
	30	12.6	N.E.	6	N.E.	7						3			17	0		
Dec.	1	12.9	N.E.	3	S.E.	1		16½	2	18½	60	1	2		17	6		
	2	12.8	N.E.	1	N.E.	1						3	8	1	18	6	4 00	Steamer Mariner, 18′ 6″, bound out, at 5 p. m. grounded on west side of channel near lower can; got off and to sea at 9 p. m.
	3	12.6	N.E.	2	N.E.	2						2	4		17	0		
	4	11.9	N.E.	6	E.	7		16	2½	18½	60	3	1		18	0		Rough on bar.
	5	11.5	N.E.	3	N.E.	4						1	4		18	0		
	6	11.2	E.	2	E.	2						2	1		18	6		
	7	10.8	S.W.	7	S.W.	6							7		15	0		
	8	10.7	W.	7	W.	8						3	1		14	0		Too rough to sound bar.
	9	10.8	W.NW.	1	N.	1						3	4		18	0		
	10	10.6	N.	1	0	0						1	4		18	9		
	11	10.5	S.SW.	1	N.W.	1		16	2½	18½	60	3	4	1	18	0	5 00	Steamer Yazoo, bound in, at 7 a. m. disabled her machinery and grounded to the westward of Wreck Can; got off and passed in at 12 m.
	12	10.6	0	0	N.W.	1							9		19	0		
	13	10.7	N.W.	1	W.	1						6			17	5		
	14	10.7	N.NE.	2	N.NE.	2	1 45					5	3		17	6		
	15	10.6	E.SE.	2	S.	2	3 15	16	2½	18½	60	4	3	1	19	3	6 00	Bark N. S., 13′, sailing in, at 7 a. m. grounded east of channel; got off and passed in at 1 p. m.
	16	10.8	S.W.	1	S.	1						2	7	1	19	0	2 00	Steamer New Orleans, 19′, bound out at 5 p. m., was two hours crossing the bar.
	17	10.7	N.NW.	4	N.NW.	4	5 00					4	4	1 1	19	6	89 00 6 00	Ship Lizzie Burrill, 16′ 8″, bound out, at 11 p. m. grounded west of channel above Can 5. Steamer Yazoo, 19′ 6″, bound out at 4 p. m., was six hours crossing the bar.
	18	10.9	N.	3	N.NE.	3	5 00	16	1½	17½	60	6	2		17	6		
	19	11.1	N.NE.	2	N.E.	2						6	8		18	0		
	20	11.2	E.	2	E.	2						15	2		16	0		
	21	11.1	E.SE.	2	E.SE.	2						5	2		19	3		Ship Lizzie Burrill got off bar at 4 p. m.
	22	11.2	0	0	E.SE.	2		16	2	18	70	7	3		17	6		
	23	11.2	S.E.	1	S.E.	2						5	2		18	6		
	24	11.1	S.E.	1	S.	2						11	2		18	0		
	25	10.9	S.SE.	2	S.SE.	2		16	2½	18½	70	12	3		17	0		
	26	10.6	S.SE.	1	S.SE.	1						7	4		17	6		
	27	10.5	S.SE.	2	S.SE.	2						5	1		15	0		
	28	10.4	S.E.	2	S.E.	3						8		1	15	6	30 00	Ship Astoria, 18′ 5″, bound out, at 3 p. m. grounded on bar.
	29	10.3	S.	2	S	2		16	2½	18½	70	6	2		18	5		Ship Astoria got off bar at 9 p. m.
	30	10.3	E.	2	E.	2	3 45					4	13	1	18	7	28 00	Ship Bohemia, 18′ 8″, bound out, at 6 p. m. grounded on west side of channel.
	31	10.1	E.	4	E.	4						9	3		18	8		Ship Bohemia got off bar at 10 p. m.
1876.																		
Jan.	1	10.0	E.	4	E.SE.	4		16	2	18	75	11	5		18	6		
	2	10.2	N.W.	2	N.W.	2						9	7		18	0		
	3	10.1	N.	2	N.	2	4 10					9	2	1	13	0	12 00	Steamer Haytien, 18′, bound out, at 9 p. m. grounded on west side of channel.
	4	10.0	N.NE.	2	N.NE.	2						9	5		18	0		Steamer Haytien got off at 9 a. m.
	5	9.6	E.	2	E.SE.	2		16	2	18	70	7	5		18	0		

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Wind at S. W. Pass. 6 a. m. Force.	Wind at S. W. Pass. 12 m. Direction.	Wind at S. W. Pass. 12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Casualties at S. W. Pass. Greatest draught.	Casualties at S. W. Pass. Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
Jan. 6	9.2	N.	2	N.	2	.....	....	....	....	....	8	5	....	19 3	.....	
7	8.6	N.	1	N.	1	.....	....	....	....	....	6	9	....	19 6	.....	
8	8.2	E. SE.	1	E. SE.	1	.....	16	2½	18½	60	9	4	1	19 0	3 15	Steamer Vanguard, 17′, bound in, at 7.30 a. m. grounded on east side of channel; got off and passed in at 10.45 a. m.
9	7.7	S. E.	2	S.	2	3 45	16	3	19	60	8	2	1	18 11	2 30	Ship J. A. Thompson, 18′ 11″, bound out, at 4 p. m. grounded on west side of channel; got off and went to sea at 6.30 p. m.
10	7.2	N.	3	N.	3	4 10	....	....	....	....	6	4	....	16 0	.....	
11	6.9	N.	4	N.	4	5 20	....	....	....	....	6	2	....	15 0	.....	
12	6.9	N.	4	N. NE.	2	4 45	....	....	....	....	3	2	1	18 0	8 00	Steamer George W. Elder, 18′, bound out, at 2 p. m. grounded on west side of channel; got off and to sea at 10 p. m.
													1		8 00	Ship Merom, 17′ 6″, bound out, at 2 p. m. grounded to the westward about Wreck Can; she got to sea at 10 p. m.
13	6.5	N. E.	4	N. E.	4	4 50	....	....	....	....	2	5	1	19 6	9 00	Ship Birmingham, 14′, bound in, at 3 p. m. grounded east of channel; got off and passed in at 12 p. m.
													1		5 00	Steamer Mississippi, 19′ 6″, bound out, at 6 p. m. grounded on bar; got off and to sea at 11 p. m.
14	6.3	N. E.	3	N. E.	3	5 00	....	....	....	....	9	2	....	16 0	.....	
15	6.1	E.	2	E.	3	.....	16	2½	18½	75	15	4	....	18 6	.....	
16	5.8	E.	2	E.	3	.....	....	....	....	....	10	3	....	16 0	.....	
17	5.6	S. E.	3	S. E.	2	.....	....	....	....	....	6	2	....	17 6	.....	
18	5.6	S. SE.	3	S.	1	.....	....	....	....	....	4	1	....	16 0	.....	
19	5.6	W.	2	W. NW.	2	.....	16	2	18	60	7	7	1	18 0	6 00	Steamer Barraindale, 18′, bound out, at 3.30 p. m. grounded on west side of channel; got off and sailed at 9.30 p. m.
20	5.6	N.	3	N. E.	2	2 40	....	....	....	....	6	10	1	19 0	2 00	Bark Georgiana, 18′ 6″, bound out at 4 p. m., was two hours crossing bar.
21	5.7	E.	2	E.	3	3 20	....	....	....	....	4	3	....	18 6	.....	
22	5.6	S. E.	2	S. E.	2	.....	16	2½	18½	75	6	2	....	18 6	.....	
23	5.9	S. E.	2	S. E.	2	.....	....	....	....	....	3	5	....	18 6	.....	
24	5.9	0	0	N. W.	1	.....	....	....	....	....	....	1	....	8 0	.....	

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	25	5.8	N. E.	1	N. E.	1	.....	.....	.....	.....	.....	1	.....	.....	13	0	.....	
	26	5.9	0	0	N. E.	2	.....	15½	2½	17½	90	4	9	...	17	0	.....	Dense fog, preventing work.
	27	5.7	S. E.	3	S. E.	3	7 20	.....	.....	.....	.....	4	3	1	18	0	117 00	Ship Success, 18′, bound out, at 3 p. m. grounded on west side of channel, near Cleopatra Buoy.
														1			3 00	Bark Porvener, 13′, bound in, at 10.30 a. m. grounded on east side of channel above Lower Cans; got off and passed in at 1.30 p. m.
	28	5.7	S. E.	3	S. SW.	4	7 05	.....	.....	.....	.....	3	3	1	17	0	4 45	Steamer Oberon, 17′, bound out, at 3.30 p. m. grounded at lower end of channel; got off and sailed at 8.15 p. m.
	29	5.5	N. W.	2	N. W.	5	1 00	...	.....	.....	.....	1	1	.....	4	0	.....	
	30	5.4	N.	4	N.	4	5 10	.....	.....	.....	.....	1	1	.....	14	0	.....	
	31	5.3	N. E.	1	N. E.	1	.....	.....	.....	.....	.....	2	1	.....	12	0	.....	
Feb.	1	5.1	S.	4	W.	3	3 00	.....	.....	.....	.....	8	1	.....	16	6	.....	Ship Success was towed inside at 12 m; rough bar.
	2	5.1	N.	5	N.	3	6 45	.....	.....	.....	.....	3	16	.....	16	6	.....	
	3	5.3	E. SE.	2	E. SE.	2	6 45	15½	2½	18	60	6	11	1	16	6	1 20	Ship Elizabeth Dougall, 16′ 3″, bound out, at 1.40 p. m. grounded on east side of channel at Lower Cans; got off at 3 p. m.
	4	5.4	W.	6	N. W.	5	4 45	.....	.....	.....	.....	2	2	.....	16	0	.....	
	5	5.3	N.	1	N.	1	9 20	15	2	17	50	4	5	1	17	0	1 00	Bark Ocean, 16′ 6″, bound out, at 2 30 p. m. grounded on west side of channel, near Lower Cans; got off and sailed at 3.30 p. m.
														1			2 00	Ship Paul Boynton, 18′, bound out, at 3.15 p. m. grounded on west side of channel, above Lower Cans; got off at 5.15 p. m.
	6	5.4	E.	2	E.	2	8 15	.....	.....	.....	.....	8	11	1	18	6	55	Steamer Bolivar, 18′, bound out, at 4 p. m. grounded just above Lower Cans; got off at 4.55 p. m.
														1			30	Steamer Frankfort, 18′ 6″, bound out, at 6 p. m. was 30 minutes crossing bar.
	7	5.1	E.	2	N. E.	3	7 10	.....	.....	.....	.....	6	6	1	18	10	20	Steamer Guillermo, 18′ 10″, bound out, at 4.50 p. m. grounded on west side of channel; got off and sailed at 5.10 p. m.
	8	5.0	E. NE.	1	N. NE.	1	.....	.....	.....	.....	.....	4	1	.....	15	6	.....	
	9	4.9	N. NE.	1	E.	2	7 20	15½	2½	18	60	7	3	1	19	0	55	Ship Adolphus, 19′, bound out, at 4.45 p. m. grounded on outside East Mud-Lump; got off at 5.40 p. m.; thick fog.
	10	4.8	S. E.	1	S. E.	1	6 55	.....	.....	.....	.....	2	2	1	16	0	45	Ship Lake Ontario, 16′, bound in, at 3 p. m. grounded on west side of channel, at Lower Cans; got off and passed in at 3.45 p. m.
	11	4.7	S. E.	1	S. E.	1	.....	.....	.....	.....	.....	3	3	1	18	0	n't kn'n	Steamer Tappahannock, 11′ 6″, bound out; dense fog; grounded east of channel, above East Mud-Lump; survey station.
	12	4.7	S. E.	1	S.	1	8 50	.....	.....	.....	.....	4	.....	.....	15	0	.....	
														1			2 50	Ship Union, 13′ 6″, bound in, at 9.30 a. m. grounded on west side of channel, at Lower Cans; towed inside at 11.20 a. m.
	13	4.6	S.	2	S. SE.	3	9 50	16	2	18	70	16	5	1	18	0	45	Bark Vesuvio, 13′, bound out, at 2.30 p. m. grounded on east side of channel, above Lower Cans; got off at 3.15 p. m.; light fog.
														1				Steamer Tappahannock got off and sailed at 6 a. m.
														1			6 15	Schooner Daisy E. Parkhurst, 12′, sailing out, at 9 a. m. grounded at lower end of bar; got off at 3.15 p. m.
	14	4.5	N. NW.	2	N. NW.	1	.....	.....	.....	.....	.....	2	17	1	17	6	3 40	Bark Australia, 15′ 6″, bound out, at 5.20 p. m. grounded on west side of channel at lower end of bar; got off about 9 p. m.
														1			19 30	Bark Ruby, 16′, bound out, at 1 p. m. grounded on east side of channel, at lower end of bar.
																		Bark Ruby got off and sailed at 8.30 a. m.
														1			25	Steamer Memphis, 16′ 6″, bound in, at 9.35 a. m. grounded at lower end of bar, on west side of channel; got off and passed in at 10 a. m.
	15	4.6	N. NW.	3	N. NW.	3	7 25	.....	.....	.....	.....	3	4	1	16	6	2 35	Bark Sleipner, 15′, bound out, at 4.25 p. m. grounded on west side of channel, just above Lower Cans; got off and sailed at 7 p. m.

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	6 a. m. Force.	12 m. Direction.	12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
													1		6 40	Ship Zelandia, 17′, bound out, at 10.20 a. m. grounded on east side of channel, at Lower Cans; got off at 5 p. m.
Feb. 16	4.7	N. W.	1	0	0	2 55	16	2	18	70	1	6	1	17 0	24 50	Bark Embla, 14′, bound out, at 10.20 a. m. grounded on west side of channel, at Lower Cans.
													1		16 15	Bark Albert, 16′, bound out, at 6 p. m. grounded on east side of channel, at Lower Cans.
																Bark Embla got off and sailed at 11.10 a. m. Bark Albert got off and sailed at 10.15 a. m.
17	4.6	N.	2	E.NE.	2	2 05	....	....	....	....	5	6	1	16 0	2 15	Steamer Margaret, 13′, bound out, at 6.30 a. m., without pilot, grounded on west side of channel, at Lower Cans; got off and sailed at 8.45 a. m.
													1		75 15	Steamer San Marcas, 18′ 3″, bound out, at 2 p. m. grounded in channel, just below Can 5.
18	4.6	N.NE.	4	N.NE.	4	2 45	....	....	....	....	2	1	1	9 0	55 25	Steamer Hudson, 15′, bound in, at 9.35 a. m. grounded just above Lower Cans, and swung across the channel.
19	4.7	N. E.	2	N. E.	2	.....	15½	2½	18	60	2	1	....	11 6	.....	Dredge-boat McAlester collided with San Marcas, breaking two of her upper plates.
20	4.6	E. NE.	2	E. NE.	2	.....	....	....	....	....	5	5	....	18 3	.....	Steamer San Marcas got off and to sea at 5.15 p. m. Steamer Hudson got off and passed in at 3 p. m.
21	4.6	S. E.	2	S. E.	2	2 10	....	....	....	....	1	4	....	14 0	.....	
22	4.5	N. E.	4	N. NE.	3	.....	....	....	....	....	4	10	....	18 3	.....	
23	4.6	N.	3	N. NW.	3	4 50	15½	2½	18	75	....	10	1	18 0	55	Ship Gen. Shepley, 15′ 6″, bound out, at 11.45 a. m. grounded on east side of channel, below Can 5; got off and sailed at 12.40 p. m.
													1		1 00	Ship John Watts, 17′, bound out, at 1 p. m. grounded at lower end of bar; got off and sailed at 2 p. m.
24	4.5	N.	2	N. NE.	2	4 05	....	....	....	....	2	11	1	18 3	2 00	Bark Tilde, 18′, bound out, at 5 p. m. grounded at lower end of bar; got off and sailed at 7 p. m.
													1		3 20	Ship David Malcomson, 18′ 3″, bound out, at 2 p. m. grounded at lower end of bar, on west side of channel; got off and sailed at 5.20 p. m.

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	25	4.4	N.	3	N.NW.	3	.....	....	....	....	....	4	8	1 1	17	8	22 30 21 20	Ship B. F. Metcalf, 16′ 8″, bound out, at 6 p. m. grounded on outer East Mud-Lump. Bark Vanguard, 18′ 10″, bound out, at 8 p. m. grounded on east side of channel, at Lower Can.
	26	4.4	E.	3	E.	3	5 00	15½	2	17½	75	2	3	....	18	10	.....	Ship B. F. Metcalf got off at 4.30 p. m. Bark Vanguard got off at 5.20 p. m.
	27	4.1	E. SE.	2	S. SW.	2	.....	....	....	....	....	3	11	1	17	0	14 4	Steamer Muriel, 17′, bound out, at 3 p. m. grounded on west side of channel, just above Can 5.
	28	4.1	E.	1	N. NE.	2	2 30	....	....	....	....	1	4	....	18	0	.....	
	29	4.2	N. E.	2	N. E.	2	.....	....	....	....	....	3	11	....	18	8	.....	
Mar.	1	4.1	S. E.	1	S. E.	1	.....	16	2	18	80	1	....	....	16	0	.....	
	2	4.3	W.NW.	2	N. NW.	3	.....	....	....	....	....	2	5	1	16	8	53 00	Ship Ryerson, 18′, bound out, at 8.30 a. m. grounded on west side of channel, below Can 5.
	3	4.0	N. E.	4	N. E.	3	4 10	....	....	....	....	....	1	....	....	....	.....	
	4	4.0	E.	2	E.	2	4 50	15½	2½	18	60	3	13	....	17	6	.....	Steamer Muriel got off and sailed at 3 p. m.
	5	4.2	E.	2	E. SE.	2	1 15	....	....	....	....	2	3	1	19	3	102 00	Ship Ryerson passed out at 1.30 p. m. Ship Success, 18′, bound out, at 4 p. m. grounded west of channel, at lower end of bar.
	6	4.0	S. E.	5	S. E.	4	.....	....	....	....	....	2	....	....	14	0	.....	
	7	4.0	N. W.	3	W.	2	6 00	....	....	....	....	8	8	...	15	6	.....	
	8	4.2	N.	2	E.	2	9 00	15	2½	17½	50	4	9	....	17	0	.....	
	9	4.1	E.	2	E.	2	4 35	....	....	....	....	6	11	1 1 ..	18	6	1 00 30	Bark Poolscar, 18′ 2″, bound out, at 1 p. m. grounded at lower end of bar; got off at 2 p. m. Steamer Andean, 18′ 6″, bound out, at 4.30 p. m. stuck 30 minutes on outside lump. Ship Success, 18′, got off and passed out at 10 p. m.
	10	3.9	S.E.	2	S. E.	2	2 40	....	....	....	....	4	8	1	19	4	3 30	Ship Agnes Sutherland, 19′ 4″, bound out, at 3 p. m. grounded at lower end of bar; got off at 6.30 p. m.
	11	3.9	E. SE.	2	S. E.	2	.....	....	....	....	....	2	....	1	15	0	17 00	Rough bar. Ship Raphael, 19′, bound out, at 4.20 p. m. grounded on west side of channel, just above Lower Cans.
	12	3.7	N. NE.	2	S. E.	1	8 25	...	....	....	....	3	6	1	19	0	2 40	Ship Raphael got off and passed out at 9.20 a. m. Ship Prince Leopold, 18′ 10″, bound out, at 1 p. m. grounded on west side of channel, below Can 5; got off and sailed at 3.40 p. m.
	13	3.8	N.	3	E.	3	9 25	15½	2½	18	60	2	11	1	18	7	2 30	Ship John Mann, 18′ 7″, bound out, at 7.45 a. m. grounded at lower end of bar; she got off at 10.15 a. m.
	14	3.8	E.	2	E.	2	5 35	....	....	....	....	1	8	....	18	6	.....	
	15	3.7	E. SE.	2	E. SE.	4	.....	16	2½	18½	80	6	3	....	19	0	.....	
	16	3.8	W.	2	W.	2	5 10	....	....	....	....	2	9	....	17	0	.....	
	17	3.8	N. E.	1	N. E.	1	10 55	....	....	....	....	6	3	....	18	6	.....	
	18	4.0	N.	4	N.	4	.....	16	2	18	70	3	....	1	13	0	30 00	Steamer Alice, 14′ 6″, bound in, at 12.10 a. m. grounded on west side of channel, above Lower Cans.
	19	3.9	E.	5	E.	7	.....	....	....	....	....	2	1	....	16	6	.....	
	20	4.0	W.	4	W.	4	.....	....	....	....	....	1	1	....	14	6	.....	Steamer Alice, 14′ 6″, got off and passed in at 6 a. m.
	21	4.1	N. W.	3	N.W.	3	11 00	...	....	....	....	....	10	1 1	17	0	2 30 23 45	Steamer Fire Queen, 16′, grounded at lower end of bar, on west side of channel; got off and sailed at 9.30 a. m. Ship Mataura, 18′, bound out, at 5.15 p. m. grounded on east side of channel, at Lower Cans.
	22	4.2	N.	1	N. E.	2	10 10	16	2½	18½	60	3	4	....	18	0	.....	Ship Mataura got off and went to sea at 5 p. m.
	23	4.0	E.	3	S. E.	4	3 40	....	....	....	....	4	9	1 1	19	4	1 15 23 30	Ship Prince Eugene, 19′ 4″, bound out, at 4 p. m. grounded on west side of channel; got off at 5.15 p. m. Ship Adept, 19′ 2″, bound out, at 6.30 p. m. grounded on east side of channel, above Lower Can.

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Wind at S. W. Pass. 6 a. m. Force.	Wind at S. W. Pass. 12 m. Direction.	Wind at S. W. Pass. 12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Casualties at S. W. Pass. Greatest draught.	Casualties at S. W. Pass. Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
Mar. 24	3.6	S.	4	N.W.	9	6 20	....	....	....	....	5	1	1	19 2	61 30	Ship Adept got off and sailed at 6 p. m. Steamer Mississippi, 18′ 9″, bound out, at 7 p. m. grounded at lower end of bar, on east side of channel.
25	3.8	W.	2	N.	1	11 40	15½	2	17½	60	1	....	....	10 0	.....	
26	3.8	S. W.	1	S. SW.	2	8 30	....	....	....	....	4	....	1 1	16 0	1 05 10 00	Steamer Charles W. Lord, 13′ 6″, bound in, at 9.30 a. m. grounded west of channel; got off and passed in at 10.35 a. m. Brig Flora Goodale, about 13′, bound out, at 1 p. m. grounded west of Lower West Can Buoy; got off at 11 p. m.
27	3.6	S. E.	3	S. E.	3	.....	....	....	....	....	3	8	....	18 9	.....	Steamer Mississippi, 18′ 9″, got off and went to sea at 8.30 a. m.
28	3.6	W.	5	W.	5	.....	....	....	....	....	....	2	....	10 0	.....	
29	3.7	N. NW.	2	N.	1	4 40	16	2½	18½	60	3	14	1 1 1	18 0	1 50 2 10 9 45	Bark Osterlide, 16′, bound out, at 7 a. m. grounded on west side of channel, at Cleopatra Buoy; got off and sailed at 8.50 a. m. Bark Orina, 17′ 6″, bound out, at 12.30 p. m. grounded on west side of channel, above Lower Can; got off at 2.40 p. m. Bark Dominico Lanata, 15′, bound out, at 9.15 a. m. grounded on west side of channel, at Lower Can.
30	3.8	0	0	S. E.	1	8 20	....	....	....	....	....	9	....	17 0	.....	Bark Dominico Lanata, 15′, got off and sailed at 7 a. m.
31	3.9	E.	2	E. SE.	3	7 00	....	....	....	....	4	7	....	18 0	.....	
Apr. 1	3.7	E. SE.	3	E. SE.	3	.....	....	....	....	....	2	1	....	16 0	.....	Rough bar; foggy.
2	3.5	S. SE.	2	S. SE.	2	.....	16	2½	18½	60	2	....	....	10 0	.....	Thick fog.
3	3.6	W.	2	W.	2	2 05	....	....	....	....	5	8	1	18 0	35	Ship Adriana, 18′, bound out at 1.45 p. m., was 35 minutes crossing the bar.
4	3.9	W.	1	S. W.	1	.....	....	....	....	....	1	....	1	17 6	46 00	Steamer Texas, 17′ 6″, bound in, at 7 a. m. grounded on east side of channel at lower end of bar.
5	4.0	S. E.	2	S. E.	2	7 40	16	2	18	40	4	4	1	17 0	24 25	Bark Virtuosa, 17′, bound out, at 4.35 p. m. grounded on east side of channel, at lower end of bar.
6	3.9	E.	3	N. E.	3	6 00	....	....	....	....	3	5	....	17 6	.....	Steamer Texas, 17′ 6″, passed in at 5 p. m. Bark Virtuosa, 17′, passed out at 5 p. m.

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	7	3.7	N. E.	2	E.	2	10 25	....	....	....	....	1	3	....	16	6	.....	
	8	3.7	W.	3	W.	3	.....	....	....	....	....	3	5	1	18	5	1 00	Rough bar. Steamer Dhoolia 18′ 5″, bound out at 7.30 a. m., was one hour crossing the bar.
	9	3.7	N.	1	E.	2	.....	16	2½	18½	90	6	8	1 1	18	0	40 1 00	Bark Siberia, 18′, bound out at 8.20 a. m., was 40 minutes crossing the bar. Ship D. W. Chapman, 17′, bound out, at 11.20 a. m. grounded on Outer Lump; got off at 12.20 p. m.
	10	3.6	N. E.	1	E.	2	5 25	....	....	....	....	1	3	1	18	6	2 00	Ship Thornhill, 18′ 6″, bound out, at 7.50 a. m. grounded at lower end of bar; got off at 9.50 a. m.
	11	3.5	E.	2	E.	2	.....	....	....	....	....	2	1	....	15	0	.....	
	12	3.7	S. E.	2	S. E.	2	.....	....	....	....	....	3	2	....	18	0	.....	Foggy; rough bar.
	13	3.5	S. E.	3	S. E.	3	.....	....	....	....	....	2	3	1	17	0	1 15	Steamer Frankfort, 17′, bound in, at 3.30 p. m. grounded on east side of channel, above Lower Cans; passed in at 4.45 p. m.
	14	3.5	N. W.	4	N. W.	3	5 00	....	....	....	....	1	6	1	16	0	23 00	Ship Wm. Douglas, 18′, bound out, at 12.30 p. m. grounded on east side of channel.
																	.....	Ship Wm. Douglas, 18′, bound out, got off bar and went to sea at 11.30 a.m.
	15	3.6	N.	2	N. NE.	2	3 20	16	2	18	100	2	9	1 1	18	2	1 05 1 35	Ship Westfield, 18′ 2″, bound out, at 12.30 p. m. grounded on west side of channel; got off at 1.35 p. m. Ship Sam Scholfield, 18′, bound out, at 2.15 p. m. grounded at first spar below Can 5; got off at 3.50 p. m.
	16	4.0	S. W.	1	S. W.	1	.....	....	....	....	....	1	6	....	18	9	.....	
	17	4.0	W.	3	W.	3	.....	....	....	....	....	3	....	....	14	0	.....	
	18	3.9	S.	2	N. E.	2	5 45	....	....	....	....	1	5	....	16	6	.....	
	19	3.9	S. E.	2	E.	2	10 20	16	2	18	60	2	6	1	17	0	15	Bark Bertha, 17′, bound out, at 10.30 a. m. grounded on east side of channel, at Can 5; got off at 10.45 a. m.
	20	3.8	S. E.	2	E.	2	7 30	....	....	....	....	3	3	....	18	0	.....	
	21	3.7	N. E.	2	N. E.	2	.....	....	....	....	....	3	1	....	15	0	.....	
	22	3.5	N. E.	1	N. E.	1	.....	....	....	....	....	2	....	1	18	0	24 15	Bark Brothers and Sisters, 18′, bound out, at 5.30 a. m. grounded at lower end of bar, on west side of channel.
	23	3.6	S. E.	2	S. E.	1	3 45	16	2½	18½	80	5	5	....	18	0	.....	Bark Brothers and Sisters, 18′, bound out, got off bar at 5.45 a. m.
	24	3.3	0	0	S.	1	.....	....	....	....	....	2	4	1	18	7	21 30	Ship City of Richmond, 17′, bound out, at 12 m. grounded on east side of channel.
	25	3.3	N. W.	3	N. W.	3	.....	....	....	....	....	....	6	....	17	0	.....	Ship City of Richmond, 17′, got off at 9.30 a. m.
	26	3.4	N. E.	2	N. E.	2	7 00	16	2½	18½	60	....	4	1	18	0	21 45	Ship N. Mosher, 18′ 7″, bound out, at 9. a. m. grounded on west side of channel.
	27	3.2	S. E.	2	S. E.	2	3 00	....	....	..	....	1	4	1	18	7	17 00	Ship N. Mosher, 18′ 7″, bound out, got off and sailed at 6.45 a. m.
	28	3.1	S.	2	0	0	.....	....	....	....	....	2	10	....	18	2	.....	Steamer Hudson, 17′ 6″, bound out, got off and went to sea at 8 a. m.
	29	3.2	N.	1	N. E.	1	4 35	16	2	18	60	....	....	....	....	....	.....	
	30	3.0	0	0	S.	1	.....	....	....	....	....	5	4	....	18	0	.....	
May	1	3.3	S.	2	S.	2	.....	....	....	....	....	4	1	....	15	0	.....	
	2	3.1	S. W.	3	S. W.	4	.....	....	....	....	....	2	1	1	8	0	66 30	Steamer Memphis, 17′ 6″, bound in, at 10.30 a. m. grounded on east side of channel, at Lower Cans.
	3	3.3	N.	4	N. NE.	3	10 40	....	....	....	....	2	1	....	10	0	.....	
	4	3.3	S.	2	S.	2	4 15	15½	2	17½	70	4	5	1	16	6	20	Ship Arcturus, 16′ 6″, bound out, at 2.45 p. m. grounded on Outer Lump; got off at 3.05 p. m.
	5	3.2	S. E.	2	S. E.	2	.....	....	....	....	....	4	6	....	18	4	.....	Steamer Memphis, 17′ 6″, passed in, at 5 a. m.
	6	3.1	S. E.	3	S. E.	3	45	....	....	....	....	7	4	1 1	19	0	50 24 00	Ship Advance, 19′, bound out, at 5.45 a. m. grounded at lower end of bar; got off at 6.35 a. m. Bark ——, 17′, bound out, at 11.30 a. m. grounded on west side of channel, below Can 5.
	7	2.9	S. E.		S. E	2	.....	....	....	....	....	5	3	....	17	0	.....	Bark —— got off at 11.30 a. m.

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Force.	12 m. Direction.	Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Feet.*	*h. m.*	
May 8	2.9	W.	7	S.	1	5 30	....	....	....	....	4	1	1	18 9	2 00	Ship City of Liverpool, 18′ 9″, bound out at 6.30 a. m., was 2 hours crossing bar.
9	3.1	N. W.	3	N. NE.	3	20	....	....	....	....	6	....	....	17 6	.....	
10	3.0	N. E.	1	E.	1		16	2½	18½	70	5	3	....	18 0	.....	
11	3.1	N.	1	N. E.	1		14½	2	16½	80	1	3	....	18 6	.....	
12	3.1	N.	1	E.	2	Delayed by accident to rudder.	....	....	....	....	8	1	1 1	15 0	2 00 62 40	Steamer Rita, 12′ 6″, bound in, at 1 a.m. grounded on east side of channel; got off and passed in at 3 p. m. Steamer Guillermo, 18′ 3″, bound out, at 12.20 p. m. grounded on west side of channel, at lower end of bar.
13	3.1	N.	1	N.	1		15½	2	17½	80	2	....	....	12 0	.....	
14	3.1	N.	1	N.	1		....	....	....	....	3	2	....	13 6	.....	
15	3.1	S. E.	2	S. E.	2		....	....	....	....	6	2	1	18 3	19 45	Steamer Guillermo, 18′ 3″, passed out at 1.30 p. m. Bark Tolomeo, 16′, bound in, at 6.15 p. m. grounded on west side of channel, above Lower Cans.
16	3.2	E.	2	E.	2		....	....	....	....	4	1	....	16 6	.....	Bark Tolomeo passed in at 2 p. m.
17	3.1	E.	2	E.	2		....	....	....	....	1	1	....	16 0	.....	
18	3.2	E.	1	E.	1	5 20	....	....	....	....	2	2	1	17 6	38 30	Ship Birmingham, 17′ 6″, bound out, at 11.30 a. m. grounded on west side of channel, below Can 5.
19	3.1	S. E.	2	S. E.	2	9 25	....	....	....	....	1	2	....	9 0	.....	
20	3.1	S. E.	2	S. E.	2	7 30	....	....	....	....	4	1	....	17 6	.....	Ship Birmingham, 17′ 6″, bound out, got off at 2 a. m.
21	3.1	S.	1	S.	1	.....	16	2	18	50	....	3	1	17 6	14 40	Steamer Hanover, 17′ 6″, bound out, at 3.40 p. m. grounded on west side of channel at Can 5.
22	3.1	S.	2	0	0	.....	....	....	....	....	2	2	....	18 0	.....	Steamer Hanover got off at 6.20 a. m.
23	3.1	S. E.	1	S. E.	1	6 20	....	....	....	....	1	4	....	18 0	.....	
24	3.2	0	0	E.	1	.....	15½	2½	18	60	8	4	....	17 6	.....	
25	3.2	E.	1	E.	1	6 15	....	....	....	....	2	1	....	14 0	.....	
26	3.3	0	0	E.	1	.....	....	....	....	....	1	4	1	18 6	17 00	Bark Almira, 18′, bound out, at 3 p. m. grounded on west side of channel, just above Lower Can.

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	27	3.3	0	0	0	0	.....	16	2½	18½	70	.....	1	.....	18	0	.....	Bark Almira got off at 8 a. m.
	28	3.4	0	0	N. E.	2	.....	.....	.....	.....	.....	1	2	...	17	6	.....	
	29	3.3	0	0	E.	1	6 15	.....	.....	.....	.....	4	.....	.....	17	0	.....	
	30	3.4	0	0	0	0	.....	.....	.....	.....	.....	.....	3	.....	17	0	.....	
	31	3.2	S. SE.	2	S. SE.	2	.....	16	2½	18½	50	2	3	.....	16	6	.....	
June	1	3.3	S. E.	2	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	2	3.3	N. W.	5	N. E.	3	5 35	.....	.....	.....	.....	1	2	...	15	6	.....	
	3	3.2	W.	2	N. W.	2	.....	16	2½	18½	50	3	3	1	16	6	4 00	Ship Her Majesty, 13′, bound in, at 6 p. m. grounded at lower end of bar; got off and passed in at 10 p. m.
	4	3.3	N. W.	1	N. W.	1	.....	.....	.....	.....	.....	1	1	.....	.....	.....	.....	
	5	3.3	N.	1	N. E.	1	.....	.....	.....	.....	.....	3	3	.....	18	0	.....	
	6	3.3	N. E.	1	N. E.	1	8 35	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	
	7	3.4	N. E.	1	E.	2	.....	16	2½	18½	60	.....	.....	1	.....	.....	21 30	Steamer Andean, 18′ 6″, bound out, at 6.30 a. m. grounded at lower end of bar.
	8	3.4	S. E.	3	S. E.	3	.....	.....	.....	.....	.....	2	13	.....	18	6	.....	Steamer Andean got off at 4 a.m. Dredge-boat McAlester left Southwest Pass for city at 3.35 p. m.
	9	3.7	S. E.	1	E.	1	.....	.....	.....	.....	.....	3	5	.....	.....	.....	.....	
	10	3.7	E.	1	N. E.	1	.....	.....	.....	.....	.....	3	2	.....	.....	.....	.....	
	11	3.5	N. E.	1	N. E.	1	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	
	12	3.7	S. W.	1	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	The dredge-boat Essayons arrived at Southwest Pass at 5.30 p. m., from New Orleans, after undergoing extensive repairs.
	13	3.6	S. W.	2	S. E.	2	.....	.....	.....	.....	.....	2	3	.....	16	6	.....	
	14	3.9	S. W.	2	S. W.	4	.....	.....	.....	.....	.....	.....	1	.....	16	0	.....	
	15	3.9	S. W.	2	W.	5	.....	15½	2½	17½	70	1	1	.....	16	6	.....	
	16	3.9	S. W.	5	S. W.	5	.....	.....	.....	.....	.....	1	3	.....	17	0	.....	
	17	3.9	S. W.	3	S. W.	3	6 00	16	2½	18½	70	.....	1	.....	17	9	.....	
	18	4.2	S. W.	5	S. W.	7	4 00	.....	.....	.....	.....	.....	1	1	13	0	17 00	Ship Oncle Felix, 18′, grounded on east side of channel at 12 m.
	19	4.1	S. W.	2	S. W.	2	11 00	.....	.....	.....	.....	2	2	.....	18	3	.....	Ship Oncle Felix got off and to sea at 5 a. m.
	20	4.3	S.	2	S.	2	13 00	.....	.....	.....	.....	.....	1	1	18	2	22 00	Ship Baden, 19′, bound out, grounded on west side of channel at 7 a. m.
	21	4.4	S. E.	4	S. E.	2	9 00	15½	2½	18	70	2	5	.....	19	0	.....	Ship Baden got off and to sea at 5 a. m.
	22	4.4	W.	1	W.	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	23	4.6	S. W.	1	S. W.	1	2 00	.....	.....	.....	.....	.....	1	.....	.....	.....	141 00	Steamer Muriel, 18′, bound out at 7 a. m., grounded.
	24	4.6	S. W.	3	S. W.	2	.....	15½	2½	17½	70	.....	1	.....	13	0	.....	
	25	4.7	S. W.	4	W.	3	.....	.....	.....	.....	.....	.....	2	.....	12	0	.....	
	26	4.8	S. W.	2	S. W.	3	10 00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	27	4.8	S.	3	S. E.	2	5 00	.....	.....	.....	.....	.....	2	.....	12	0	.....	
	28	4.8	S. W.	1	S. W.	5	.....	.....	.....	.....	.....	1	1	.....	8	0	.....	
	29	4.9	S.	1	S. E.	2	.....	.....	.....	.....	.....	.....	1	1	18	0	26 45	Steamer Muriel, 18′, got off and went to sea at 4 a. m. Steamer Haytien, 18′ 6″, grounded east side of channel at 7 a. m.; she got off and went to sea July 1, at 9.45 a. m.
	30	5.6	S.	1	S. E.	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Wind at S. W. Pass. 6 a. m. Force.	Wind at S. W. Pass. 12 m. Direction.	Wind at S. W. Pass. 12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Casualties at S. W. Pass. Greatest draught.	Casualties at S. W. Pass. Time of delay.	Remarks.
1875.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
Nov. 4	13.9	S. E.	4	S. E.	2	3 30	....	....	....	....	8	6	....	18 8	.....	
5	14.0	S. E.	5	S. E.	4	.....	....	....	....	....	5	1	....	18 6	.....	
6	13.7	N.	2	N.	4	.....	16	2	18	50	4	1	....	17 6	.....	
7	13.5	N. E.	5	N. E.	4	.....	....	....	....	....	2	1	....	17 0	.....	
8	13.7	N. W.	5	N. W.	4	.....	....	....	....	....	1	1	....	15 0	.....	
9	13.0	N. E.	6	E.	8	.....	....	....	....	....	2	1	....	19 6	.....	
10	14.0	N. W.	6	N. W.	7	.....	16	1½	17½	50	2	6	....	17 6	.....	
11	14.4	N. W.	2	N. W.	2	.....	....	....	....	....	2	5	....	17 6	.....	
12	14.7	W.	1	E.	2	.....	....	....	....	....	5	2	....	17 0	.....	
13	14.4	S.	2	S. E.	2	.....	16½	2½	18½	60	4	2	....	19 0	.....	
14	14.5	S. E.	4	E.	4	.....	....	....	....	....	2	4	....	18 6	.....	
15	14.7	S. W.	4	E.	5	.....	....	....	....	....	3	....	....	15 0	.....	
16	14.8	E.	1	S. W.	3	.....	....	....	....	....	2	1	....	18 2	.....	
17	14.6	N. W.	6	N. W.	6	4 00	16	2½	18½	60	4	6	....	18 0	.....	
18	14.5	S. E.	2	S. E.	4	.....	....	....	....	....	4	....	....	15 0	.....	
19	14.3	E.	1	S. E.	2	.....	....	....	....	....	2	2	....	18 8	.....	
20	14.3	E.	2	S. E.	3	.....	16	2½	18½	60	5	1	....	17 0	.....	
21	14.1	E.	1	S. E.	1	.....	....	....	....	....	2	3	1	18 6	10 00	Steamer Castilla, 18′ 6″, bound out, grounded on west side of channel, near Can 4, at 5 p. m.
22	13.9	S. E.	3	N. E.	4	.....	....	....	....	....	2	4	1	18 0	7 00	Steamer Castilla got off and went to sea at 3 a. m. Steamer Durham, 18′ 6″, bound out, at 10 a. m. grounded on west side of channel, near Cleopatra Buoy. Steamer Durham got off and went to sea at 5 p. m.
23	13.7	N. E.	4	S. E.	5	.....	....	....	....	....	4	2	....	18 6	.....	
24	13.5	E.	1	N.	5	.....	16½	1½	18	60	1	5	1 1	18 6	3 00 7 00	Steamer Paschal, 18′ 6″, bound out, at 9 a. m. grounded on west side of channel, near last buoy; got off and went to sea at 12 m. Steamer Texas, 18′ 6″, bound out, at 5 p. m. grounded on west side of channel, near last buoy; got off and went to sea at 12 p. m.
25	13.5	N. E.	7	N. E.	4	.....	....	....	....	....	4		....	18 6	.....	

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	26	13.3	S.	3	S.	1	.....	.....	.....	.....	.....	3	.....	.....	17	0	.....	
	27	13.5	E.	1	N.	2	.....	16½	2	18½	60	2	.....	.....	15	0	.....	
	28	13.4	N. E.	2	E.	2	.....	.....	.....	.....	.....	3	7	.....	17	0	.....	
	29	13.0	N. E.	2	N.	2	.....	.....	.....	.....	.....	1	.....	.....	15	0	.....	
	30	12.6	N. E.	6	N. E.	7	.....	.....	.....	.....	.....	3	.....	.....	17	0	.....	
Dec.	1	12.9	N. E.	3	S. E.	1	.....	16½	2	18½	60	1	2	.....	17	6	.....	
	2	12.8	N. E.	1	N. E.	1	.....	.....	.....	.....	.....	3	8	1	18	6	4 00	Steamer Mariner, 18′ 6″, bound out, at 5 p. m. grounded on west side of channel near lower can; got off and to sea at 9 p. m.
	3	12.6	N. E.	2	N. E.	2	.....	.....	.....	.....	.....	2	4	.....	17	0	.....	
	4	11.9	N. E.	6	E.	7	.....	16	2½	18½	60	3	1	.....	18	0	.....	Rough on bar.
	5	11.5	N. E.	3	N. E.	4	.....	.....	.....	.....	.....	1	4	.....	18	0	.....	
	6	11.2	E.	2	E.	2	.....	.....	.....	.....	.....	2	1	.....	18	6	.....	
	7	10.8	S. W.	7	S. W.	6	.....	.....	.....	.....	.....	.....	7	.....	15	0	.....	
	8	10.7	W.	7	W.	8	.....	.....	.....	.....	.....	3	1	.....	14	0	.....	Too rough to sound bar.
	9	10.8	W.NW.	1	N.	1	.....	.....	.....	.....	.....	3	4	.....	18	0	.....	
	10	10.6	N.	1	0	0	.....	.....	.....	.....	.....	1	4	.....	18	9	.....	
	11	10.5	S. SW.	1	N. W.	1	.....	16	2½	18½	60	3	4	1	18	0	5 00	Steamer Yazoo, bound in, at 7 a. m. disabled her machinery and grounded to the westward of Wreck Can; got off and passed in at 12 m.
	12	10.6	0	0	N. W.	1	.....	.....	.....	.....	.....	.....	9	..	19	0	.....	
	13	10.7	N. W.	1	W.	1	.....	.....	.....	.....	.....	6	.....	.....	17	5	.....	
	14	10.7	N. NE.	2	N. NE.	2	1 45	.....	.....	.....	.....	5	3	.....	17	6	.....	
	15	10.6	E.SE.	2	S.	2	3 15	16	2½	18½	60	4	3	1	19	3	6 00	Bark N. S., 13′, sailing in, at 7 a. m. grounded east of channel; got off and passed in at 1 p. m.
	16	10.8	S. W.	1	S.	1	.....	.....	.....	.....	.....	2	7	1	19	0	2 00	Steamer New Orleans, 19′, bound out at 5 p. m., was two hours crossing the bar.
	17	10.7	N. NW.	4	N. NW.	4	5 00	.....	.....	.....	.....	4	4	1 1	19	6	89 00 6 00	Ship Lizzie Burrill, 16′ 8″, bound out, at 11 p. m. grounded west of channel above Can 5. Steamer Yazoo, 19′ 6″, bound out at 4 p. m., was six hours crossing the bar.
	18	10.9	N.	3	N. NE.	3	5 00	16	1½	17½	60	6	2	.....	17	6	.....	
	19	11.1	N. NE.	2	N. E.	2	.....	.....	.....	.....	.....	6	8	.....	18	0	.....	
	20	11.2	E.	2	E.	2	.....	.....	.....	.....	.....	15	2	.....	16	0	.....	
	21	11.1	E. SE.	2	E. SE.	2	.....	.....	.....	.....	.....	5	2	.....	19	3	.....	Ship Lizzie Burrill got off bar at 4 p. m.
	22	11.2	0	0	E. SE.	2	.....	16	2	18	70	7	3	.....	17	6	.....	
	23	11.2	S. E.	1	S. E.	2	.....	.....	.....	.....	.....	5	2	.....	18	6	.....	
	24	11.1	S. E.	1	S.	2	.....	.....	.....	.....	.....	11	2	.....	18	0	.....	
	25	10.9	S. SE.	2	S. SE.	2	.....	16	2½	18½	70	12	3	.....	17	0	.....	
	26	10.6	S. SE.	1	S. SE.	1	.....	.....	.....	.....	.....	7	4	.....	17	6	.....	
	27	10.5	S. SE.	2	S. SE.	2	.....	.....	.....	.....	.....	5	1	.....	15	0	.....	
	28	10.4	S. E.	2	S. E.	3	.....	.....	.....	.....	.....	8	.....	1	15	6	30 00	Ship Astoria, 18′ 5″, bound out, at 3 p. m. grounded on bar.
	29	10.3	S.	2	S	2	.....	16	2½	18½	70	6	2	.....	18	5	.....	Ship Astoria got off bar at 9 p. m.
	30	10.3	E.	2	E.	2	3 45	.....	.....	.....	.....	4	13	1	18	7	28 00	Ship Bohemia, 18′ 8″, bound out, at 6 p. m. grounded on west side of channel.
	31	10.1	E.	4	E.	4	.....	.....	.....	.....	.....	9	3	.....	18	8	.....	Ship Bohemia got off bar at 10 p. m.
1876.																		
Jan.	1	10.0	E.	4	E. SE.	4	.....	16	2	18	75	11	5	.....	18	6	.....	
	2	10.2	N. W.	2	N. W.	2	.....	.....	.....	.....	.....	9	7	.....	18	0	.....	
	3	10.1	N.	2	N.	2	4 10	.....	.....	.....	.....	9	2	1	13	0	12 00	Steamer Haytien, 18′, bound out, at 9 p. m. grounded on west side of channel.
	4	10.0	N. NE.	2	N. NE.	2	.....	.....	.....	.....	.....	9	5	.....	18	0	.....	Steamer Haytien got off at 9 a. m.
	5	9.6	E.	2	E. SE.	2	.....	16	2	18	70	7	5	.....	18	0	.....	

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Force.	12 m. Direction.	Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
Jan. 6	9.2	N.	2	N.	2	.....	....	....	....	....	8	5	....	19 3	.....	
7	8.6	N.	1	N.	1	.....	....	....	....	....	6	9	....	19 6	.....	
8	8.2	E. SE.	1	E. SE.	1	.....	16	2½	18½	60	9	4	1	19 0	3 15	Steamer Vanguard, 17′, bound in, at 7.30 a. m. grounded on east side of channel; got off and passed in at 10.45 a. m.
9	7.7	S. E.	2	S.	2	3 45	16	3	19	60	8	2	1	18 11	2 30	Ship J. A. Thompson, 18′ 11″, bound out, at 4 p. m. grounded on west side of channel; got off and went to sea at 6.30 p. m.
10	7.2	N.	3	N.	3	4 10	....	....	....	....	6	4	....	16 0	.....	
11	6.9	N.	4	N.	4	5 20	....	....	....	....	6	2	....	15 0	.....	
12	6.9	N.	4	N. NE.	2	4 45	....	....	....	....	3	2	1	18 0	8 00	Steamer George W. Elder, 18′, bound out, at 2 p. m. grounded on west side of channel; got off and to sea at 10 p. m.
													1		8 00	Ship Merom, 17′ 6″, bound out, at 2 p. m. grounded to the westward about Wreck Can; she got to sea at 10 p. m.
13	6.5	N. E.	4	N. E.	4	4 50	....	....	....	....	2	5	1	19 6	9 00	Ship Birmingham, 14′, bound in, at 3 p. m. grounded east of channel; got off and passed in at 12 p. m.
													1		5 00	Steamer Mississippi, 19′ 6″, bound out, at 6 p. m. grounded on bar; got off and to sea at 11 p. m.
14	6.3	N. E.	3	N. E.	3	5 00	....	....	....	....	9	2	....	16 0	.....	
15	6.1	E.	2	E.	3	.....	16	2½	18½	75	15	4	....	18 6	.....	
16	5.8	E.	2	E.	3	.....	....	....	....	....	10	3	....	16 0	.....	
17	5.6	S. E.	3	S. E.	2	.....	....	....	....	....	6	2	....	17 6	.....	
18	5.6	S. SE.	3	S.	1	.....	....	....	....	....	4	1	....	16 0	.....	
19	5.6	W.	2	W. NW.	2	.....	16	2	18	60	7	7	1	18 0	6 00	Steamer Barraindale, 18′, bound out, at 3.30 p. m. grounded on west side of channel; got off and sailed at 9.30 p. m.
20	5.6	N.	3	N. E.	2	2 40	....	....	....	....	6	10	1	19 0	2 00	Bark Georgiana, 18′ 6″, bound out at 4 p. m., was two hours crossing bar.
21	5.7	E.	2	E.	3	3 20	....	....	....	....	4	3	....	18 6	.....	
22	5.6	S. E.	2	S. E.	2	.....	16	2½	18½	75	6	2	....	18 6	.....	
23	5.9	S. E.	2	S. E.	2	.....	....	....	....	....	3	5	....	18 6	.....	
24	5.9	0	0	N. W.	1	.....	....	....	....	....	....	1	....	8 0	.....	

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	25	5.8	N. E.	1	N. E.	1	.....	.....	.....	.....	.....	1	.....	.....	13	0	.....	
	26	5.9	0	0	N. E.	2	.....	15½	2½	17½	90	4	9	.....	17	0	.....	Dense fog, preventing work.
	27	5.7	S. E.	3	S. E.	3	7 20	.....	.....	.....	.....	4	3	1	18	0	117 00	Ship Success, 18′, bound out, at 3 p. m. grounded on west side of channel, near Cleopatra Buoy.
														1			3 00	Bark Porvener, 13′, bound in, at 10.30 a. m. grounded on east side of channel above Lower Cans; got off and passed in at 1.30 p. m.
	28	5.7	S. E.	3	S. SW.	4	7 05	.....	.....	.....	.....	3	3	1	17	0	4 45	Steamer Oberon, 17′, bound out, at 3.30 p. m. grounded at lower end of channel; got off and sailed at 8.15 p. m.
	29	5.5	N. W.	2	N. W.	5	1 00	.....	.....	.....	.....	1	1	.....	4	0	.....	
	30	5.4	N.	4	N.	4	5 10	.....	.....	.....	.....	1	1	.....	14	0	.....	
	31	5.3	N. E.	1	N. E.	1	.....	.....	.....	.....	.....	2	1	.....	12	0	.....	
Feb.	1	5.1	S.	4	W.	3	3 00	.....	.....	.....	.....	8	1	.....	16	6	.....	Ship Success was towed inside at 12 m; rough bar.
	2	5.1	N.	5	N.	3	6 45	.....	.....	.....	.....	3	16	.....	16	6	.....	
	3	5.3	E. SE.	2	E. SE.	2	6 45	15½	2½	18	60	6	11	1	16	6	1 20	Ship Elizabeth Dougall, 16′ 3″, bound out, at 1.40 p. m. grounded on east side of channel at Lower Cans; got off at 3 p. m.
	4	5.4	W.	6	N. W.	5	4 45	.....	.....	.....	.....	2	2	.....	16	0	.....	
	5	5.3	N.	1	N.	1	9 20	15	2	17	50	4	5	1	17	0	1 00	Bark Ocean, 16′ 6″, bound out, at 2 30 p. m. grounded on west side of channel, near Lower Cans; got off and sailed at 3.30 p. m.
														1			2 00	Ship Paul Boynton, 18′, bound out, at 3.15 p. m. grounded on west side of channel, above Lower Cans; got off at 5.15 p. m.
	6	5.4	E.	2	E.	2	8 15	.....	.....	.....	.....	8	11	1	18	6	55	Steamer Bolivar, 18′, bound out, at 4 p. m. grounded just above Lower Cans; got off at 4.55 p. m.
														1			30	Steamer Frankfort, 18′ 6″, bound out, at 6 p. m. was 30 minutes crossing bar.
	7	5.1	E.	2	N. E.	3	7 10	.....	.....	.....	.....	6	6	1	18	10	20	Steamer Guillermo, 18′ 10″, bound out, at 4.50 p. m. grounded on west side of channel; got off and sailed at 5.10 p. m.
	8	5.0	E. NE.	1	N. NE.	1	.....	.....	.....	.....	.....	4	1	.....	15	6	.....	
	9	4.9	N. NE.	1	E.	2	7 20	15½	2½	18	60	7	3	1	19	0	55	Ship Adolphus, 19′, bound out, at 4.45 p. m. grounded on outside East Mud-Lump; got off at 5.40 p. m.; thick fog.
	10	4.8	S. E.	1	S. E.	1	6 55	.....	.....	.....	.....	2	2	1	16	0	45	Ship Lake Ontario, 16′, bound in, at 3 p. m. grounded on west side of channel, at Lower Cans; got off and passed in at 3.45 p. m.
	11	4.7	S. E.	1	S. E.	1	.....	.....	.....	.....	.....	3	3	1	18	0	n't kn'n	Steamer Tappahannock, 11′ 6″, bound out; dense fog; grounded east of channel, above East Mud-Lump; survey station.
	12	4.7	S. E.	1	S.	1	8 50	.....	.....	.....	.....	4	.....	.....	15	0	.....	
														1			2 50	Ship Union, 13′ 6″, bound in, at 9.30 a. m. grounded on west side of channel, at Lower Cans; towed inside at 11.20 a. m.
	13	4.6	S.	2	S. SE.	3	9 50	16	2	18	70	16	5	1	18	0	45	Bark Vesuvio, 13′, bound out, at 2.30 p. m. grounded on east side of channel, above Lower Cans; got off at 3.15 p. m.; light fog.
																		Steamer Tappahannock got off and sailed at 6 a. m.
														1			6 15	Schooner Daisy E. Parkhurst, 12′, sailing out, at 9 a. m. grounded at lower end of bar; got off at 3.15 p. m.
	14	4.5	N. NW.	2	N. NW.	1	.....	.....	.....	.....	.....	2	17	1	17	6	3 40	Bark Australia, 15′ 6″, bound out, at 5.20 p. m. grounded on west side of channel at lower end of bar; got off about 9 p. m.
														1			19 30	Bark Ruby, 16′, bound out, at 1 p. m. grounded on east side of channel, at lower end of bar.
																		Bark Ruby got off and sailed at 8.30 a. m.
														1			25	Steamer Memphis, 16′ 6″, bound in, at 9.35 a. m. grounded at lower end of bar, on west side of channel; got off and passed in at 10 a. m.
	15	4.6	N. NW.	3	N. NW.	3	7 25	.....	.....	.....	.....	3	4	1	16	6	2 35	Bark Sleipner, 15′, bound out, at 4.25 p. m. grounded on west side of channel, just above Lower Cans; got off and sailed at 7 p. m.

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Wind at S. W. Pass. 6 a. m. Force.	Wind at S. W. Pass. 12 m. Direction.	Wind at S. W. Pass. 12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Casualties at S. W. Pass. Greatest draught.	Casualties at S. W. Pass. Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
Feb. 16	4.7	N. W.	1	0	0	2 55	16	2	18	70	1	6	1		6 40	Ship Zelandia, 17′, bound out, at 10.20 a. m. grounded on east side of channel, at Lower Cans; got off at 5 p. m.
													1		24 50	Bark Embla, 14′, bound out, at 10.20 a. m. grounded on west side of channel, at Lower Cans.
													1	17 0	16 15	Bark Albert, 16′, bound out, at 6 p. m. grounded on east side of channel, at Lower Cans.
																Bark Embla got off and sailed at 11.10 a. m. Bark Albert got off and sailed at 10.15 a. m.
17	4.6	N.	2	E.NE.	2	2 05	....	....	....	....	5	6	1	16 0	2 15	Steamer Margaret, 13′, bound out, at 6.30 a. m., without pilot, grounded on west side of channel, at Lower Cans; got off and sailed at 8.45 a. m.
													1		75 15	Steamer San Marcas, 18′ 3″, bound out, at 2 p. m. grounded in channel, just below Can 5.
18	4.6	N.NE.	4	N.NE.	4	2 45	....	....	....	....	2	1	1	9 0	55 25	Steamer Hudson, 15′, bound in, at 9.35 a. m. grounded just above Lower Cans, and swung across the channel.
19	4.7	N. E.	2	N. E.	2	.....	15½	2½	18	60	2	1	....	11 6	.....	Dredge-boat McAlester collided with San Marcas, breaking two of her upper plates.
20	4.6	E. NE.	2	E. NE.	2	.....	....	....	....	....	5	5	....	18 3	.....	Steamer San Marcas got off and to sea at 5.15 p. m. Steamer Hudson got off and passed in at 3 p. m.
21	4.6	S. E.	2	S. E.	2	2 10	....	....	....	....	1	4	....	14 0	.....	
22	4.5	N. E.	4	N. NE.	3	.....	....	....	....	....	4	10	....	18 3	.....	
23	4.6	N.	3	N. NW.	3	4 50	15½	2½	18	75	....	10	1	18 0	55	Ship Gen. Shepley, 15′ 6″, bound out, at 11.45 a. m. grounded on east side of channel, below Can 5; got off and sailed at 12.40 p. m.
24	4.5	N.	2	N. NE.	2	4 05	....	....	....	....	2	11	1	18 3	1 00	Ship John Watts, 17′, bound out, at 1 p. m. grounded at lower end of bar; got off and sailed at 2 p. m.
													1		2 00	Bark Tilde, 18′, bound out, at 5 p. m. grounded at lower end of bar; got off and sailed at 7 p. m.
													1		3 20	Ship David Malcomson, 18′ 3″, bound out, at 2 p. m. grounded at lower end of bar, on west side of channel; got off and sailed at 5.20 p. m.

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	25	4.4	N.	3	N. NW.	3	.....	....	....	....	....	4	8	1	17	8	22 30	Ship B. F. Metcalf, 16′ 8″, bound out, at 6 p. m. grounded on outer East Mud-Lump.
														1			21 20	Bark Vanguard, 18′ 10″, bound out, at 8 p. m. grounded on east side of channel, at Lower Can.
	26	4.4	E.	3	E.	3	5 00	15½	2	17½	75	2	3	....	18	10	.....	Ship B. F. Metcalf got off at 4.30 p. m. Bark Vanguard got off at 5.20 p. m.
	27	4.1	E. SE.	2	S. SW.	2	.....	....	....	....	....	3	11	1	17	0	14 4	Steamer Muriel, 17′, bound out, at 3 p. m. grounded on west side of channel, just above Can 5.
	28	4.1	E.	1	N. NE.	2	2 30	....	....	....	....	1	4	....	18	0	.....	
	29	4.2	N. E.	2	N. E.	2	.....	....	....	....	....	3	11	....	18	8	.....	
Mar.	1	4.1	S. E.	1	S. E.	1	.....	16	2	18	80	1	....	....	16	0	.....	
	2	4.3	W. NW.	2	N. NW.	3	.....	....	....	....	....	2	5	1	16	8	53 00	Ship Ryerson, 18′, bound out, at 8.30 a. m. grounded on west side of channel, below Can 5.
	3	4.0	N. E.	4	N. E.	3	4 10	....	....	....	....	....	1	....	....	....	.....	
	4	4.0	E.	2	E.	2	4 50	15½	2½	18	60	3	13	....	17	6	.....	Steamer Muriel got off and sailed at 3 p. m.
																		Ship Ryerson passed out at 1.30 p. m.
	5	4.2	E.	2	E. SE.	2	1 15	....	....	....	....	2	3	1	19	3	102 00	Ship Success, 18′, bound out, at 4 p. m. grounded west of channel, at lower end of bar.
	6	4.0	S. E.	5	S. E.	4	.....	....	....	....	....	2	....	....	14	0	.....	
	7	4.0	N. W.	3	W.	2	6 00	....	....	....	....	8	8	....	15	6	.....	
	8	4.2	N.	2	E.	2	9 00	15	2½	17½	50	4	9	....	17	0	.....	
														1			1 00	Bark Poolscar, 18′ 2″, bound out, at 1 p. m. grounded at lower end of bar; got off at 2 p. m.
	9	4.1	E.	2	E.	2	4 35	....	....	....	....	6	11	1	18	6	30	Steamer Andean, 18′ 6″, bound out, at 4.30 p. m. stuck 30 minutes on outside lump.
														..			.....	Ship Success, 18′, got off and passed out at 10 p. m.
	10	3.9	S. E.	2	S. E.	2	2 40	....	....	....	....	4	8	1	19	4	3 30	Ship Agnes Sutherland, 19′ 4″, bound out, at 3 p. m. grounded at lower end of bar; got off at 6.30 p. m.
	11	3.9	E. SE.	2	S. E.	2	.....	....	....	....	....	2	....	1	15	0	17 00	Rough bar. Ship Raphael, 19′, bound out, at 4.20 p. m. grounded on west side of channel, just above Lower Cans.
																		Ship Raphael got off and passed out at 9.20 a. m.
	12	3.7	N. NE.	2	S. E.	1	8 25	...	....	....	....	3	6	1	19	0	2 40	Ship Prince Leopold, 18′ 10″, bound out, at 1 p. m. grounded on west side of channel, below Can 5; got off and sailed at 3.40 p. m.
	13	3.8	N.	3	E.	3	9 25	15½	2½	18	60	2	11	1	18	7	2 30	Ship John Mann, 18′ 7″, bound out, at 7.45 a. m. grounded at lower end of bar; she got off at 10.15 a. m.
	14	3.8	E.	2	E.	2	5 35	...	....	....	....	1	8	....	18	6	.....	
	15	3.7	E. SE.	2	E. SE.	4	.....	16	2½	18½	80	6	3	....	19	0	.....	
	16	3.8	W.	2	W.	2	5 10	...	....	....	....	2	9	....	17	0	.....	
	17	3.8	N. E.	1	N. E.	1	10 55	...	....	....	....	6	3	....	18	6	.....	
	18	4.0	N.	4	N.	4	.....	16	2	18	70	3	....	1	13	0	30 00	Steamer Alice, 14′ 6″, bound in, at 12.10 a. m. grounded on west side of channel, above Lower Cans.
	19	3.9	E.	5	E.	7	.....	....	....	....	....	2	1	....	16	6	.....	
	20	4.0	W.	4	W.	4	.....	....	....	....	....	1	1	....	14	6	.....	Steamer Alice, 14′ 6″, got off and passed in at 6 a. m.
														1			2 30	Steamer Fire Queen, 16′, grounded at lower end of bar, on west side of channel; got off and sailed at 9.30 a. m.
	21	4.1	N. W.	3	N. W.	3	11 00	...	....	....	....	....	10	1	17	0	23 45	Ship Mataura, 18′, bound out, at 5.15 p. m. grounded on east side of channel, at Lower Cans.
	22	4.2	N.	1	N. E.	2	10 10	16	2½	18½	60	3	4	....	18	0	.....	Ship Mataura got off and went to sea at 5 p. m.
														1			1 15	Ship Prince Eugene, 19′ 4″, bound out, at 4 p. m. grounded on west side of channel; got off at 5.15 p. m.
	23	4.0	E.	3	S. E.	4	3 40	....	....	....	....	4	9	1	19	4	23 30	Ship Adept, 19′ 2″, bound out, at 6.30 p. m. grounded on east side of channel, above Lower Can.

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	6 a. m. Force.	12 m. Direction.	12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
Mar. 24	3.6	S.	4	N.W.	9	6 20	....	....	....	....	5	1	1	19 2	61 30	Ship Adept got off and sailed at 6 p. m. Steamer Mississippi, 18′ 9″, bound out, at 7 p. m. grounded at lower end of bar, on east side of channel.
25	3.8	W.	2	N.	1	11 40	15½	2	17½	60	1	....	....	10 0	.....	
26	3.8	S. W.	1	S. SW.	2	8 30	....	....	....	....	4	....	1 1	16 0	1 05 10 00	Steamer Charles W. Lord, 13′ 6″, bound in, at 9.30 a. m. grounded west of channel; got off and passed in at 10.35 a. m. Brig Flora Goodale, about 13′, bound out, at 1 p. m. grounded west of Lower West Can Buoy; got off at 11 p. m.
27	3.6	S. E.	3	S. E.	3	.....	....	....	....	....	3	8	....	18 9	.....	Steamer Mississippi, 18′ 9″, got off and went to sea at 8.30 a. m.
28	3.6	W.	5	W.	5	.....	....	....	....	....	....	2	....	10 0	.....	
29	3.7	N. NW.	2	N.	1	4 40	16	2½	18½	60	3	14	1 1 1	18 0	1 50 2 10 9 45	Bark Osterlide, 16′, bound out, at 7 a. m. grounded on west side of channel, at Cleopatra Buoy; got off and sailed at 8.50 a. m. Bark Orina, 17′ 6″, bound out, at 12.30 p. m. grounded on west side of channel, above Lower Can; got off at 2.40 p. m. Bark Dominico Lanata, 15′, bound out, at 9.15 a. m. grounded on west side of channel, at Lower Can.
30	3.8	0	0	S. E.	1	8 20	....	....	....	....	....	9	....	17 0	.....	Bark Dominico Lanata, 15′, got off and sailed at 7 a. m.
31	3.9	E.	2	E. SE.	3	7 00	....	....	....	....	4	7	....	18 0	.....	
Apr. 1	3.7	E. SE.	3	E. SE.	3	.....	....	....	....	....	2	1	....	16 0	.....	Rough bar; foggy.
2	3.5	S. SE.	2	S. SE.	2	.....	16	2½	18½	60	2	....	....	10 0	.....	Thick fog.
3	3.6	W.	2	W.	2	2 05	....	....	....	....	5	8	1	18 0	35	Ship Adriana, 18′, bound out at 1.45 p. m., was 35 minutes crossing the bar.
4	3.9	W.	1	S. W.	1	.....	....	....	....	....	1	....	1	17 6	46 00	Steamer Texas, 17′ 6″, bound in, at 7 a. m. grounded on east side of channel at lower end of bar.
5	4.0	S. E.	2	S. E.	2	7 40	16	2	18	40	4	4	1	17 0	24 25	Bark Virtuosa, 17′, bound out, at 4.35 p. m. grounded on east side of channel, at lower end of bar.
6	3.9	E.	3	N. E.	3	6 00	....	....	....	....	3	5	....	17 6	.....	Steamer Texas, 17′ 6″, passed in at 5 p. m. Bark Virtuosa, 17′, passed out at 5 p. m.

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	7	3.7	N.E.	2	E.	2	10 25	....	....	....	....	1	3	....	16	6	.....	
	8	3.7	W.	3	W.	3	.....	....	....	....	....	3	5	1	18	5	1 00	Rough bar. Steamer Dhoolia 18′ 5″, bound out at 7.30 a. m., was one hour crossing the bar.
	9	3.7	N.	1	E.	2	.....	16	2½	18½	90	6	8	1 1	18	0	40 1 00	Bark Siberia, 18′, bound out at 8.30 a. m., was 40 minutes crossing the bar. Ship D. W. Chapman, 17′, bound out, at 11.20 a. m. grounded on Outer Lump; got off at 12.20 p. m.
	10	3.6	N.E.	1	E.	2	5 25	....	....	....	....	1	3	1	18	6	2 00	Ship Thornhill, 18′ 6″, bound out, at 7.50 a. m. grounded at lower end of bar; got off at 9.50 a. m.
	11	3.5	E.	2	E.	2	.....	....	....	....	....	2	1	....	15	0	.....	
	12	3.7	S.E.	2	S.E.	2	.....	....	....	....	....	3	2	....	18	0	.....	Foggy; rough bar.
	13	3.5	S.E.	3	S.E.	3	.....	....	....	....	....	2	3	1	17	0	1 15	Steamer Frankfort, 17′, bound in, at 3.30 p. m. grounded on east side of channel, above Lower Cans; passed in at 4.45 p. m.
	14	3.5	N.W.	4	N.W.	3	5 00	....	....	....	....	1	6	1	16	0	23 00	Ship Wm. Douglas, 18′, bound out, at 12.30 p. m. grounded on east side of channel.
																	.....	Ship Wm. Douglas, 18′, bound out, got off bar and went to sea at 11.30 a.m.
	15	3.6	N.	2	N.NE.	2	3 20	16	2	18	100	2	9	1 1	18	2	1 05 1 35	Ship Westfield, 18′ 2″, bound out, at 12.30 p. m. grounded on west side of channel; got off at 1.35 p. m. Ship Sam Schonfield, 18′, bound out, at 2.15 p. m. grounded at first spar below Can 5; got off at 3.50 p. m.
	16	4.0	S.W.	1	S.W.	1	.....	....	....	....	....	1	6	....	18	9	.....	
	17	4.0	W.	3	W.	3	.....	....	....	....	....	3	....	....	14	0	.....	
	18	3.9	S.	2	N.E.	2	5 45	....	....	....	....	1	5	....	16	6	.....	
	19	3.9	S.E.	2	E.	2	10 20	16	2	18	60	2	6	1	17	0	15	Bark Bertha, 17′, bound out, at 10 30 a. m. grounded on east side of channel, at Can 5; got off at 10.45 a. m.
	20	3.8	S.E.	2	E.	2	7 30	....	....	....	....	3	3	....	18	0	.....	
	21	3.7	N.E.	2	N.E.	2	.....	....	....	....	....	3	1	....	15	0	.....	
	22	3.5	N.E.	1	N.E.	1	.....	....	....	....	....	2	....	1	18	0	24 15	Bark Brothers and Sisters, 18′, bound out, at 5.30 a. m. grounded at lower end of bar, on west side of channel.
	23	3.6	S.E.	2	S.E.	1	3 45	16	2½	18½	80	5	5	....	18	0	.....	Bark Brothers and Sisters, 18′, bound out, got off bar at 5.45 a. m.
	24	3.3	0	0	S.	1	.....	....	....	....	....	2	4	1	18	7	21 30	Ship City of Richmond, 17′, bound out, at 12 m. grounded on east side of channel.
	25	3.3	N.W.	3	N.W.	3	.....	....	....	....	....	....	6	....	17	0	.....	Ship City of Richmond, 17′, got off at 9.30 a. m.
	26	3.4	N.E.	2	N.E.	2	7 00	16	2½	18½	60	....	4	1	18	0	21 45	Ship N. Mosher, 18′ 7″, bound out, at 9. a. m. grounded on west side of channel.
	27	3.2	S.E.	2	S.E.	2	3 00	....	....	..	....	1	4	1	18	7	17 00	Ship N. Mosher, 18′ 7″, bound out, got off and sailed at 6.45 a. m. Steamer Hudson, 17′ 6″, bound out, got off and went to sea at 8 a. m.
	28	3.1	S.	2	0	0	.....	....	....	....	....	2	10	....	18	2	.....	
	29	3.2	N.	1	N.E.	1	4 35	16	2	18	60	....	....	....	....	....	.....	
	30	3.0	0	0	S.	1	.....	....	....	....	....	5	4	....	18	0	.....	
May	1	3.3	S.	2	S.	2	.....	....	....	....	....	4	1	....	15	0	.....	
	2	3.1	S.W.	3	S.W.	4	.....	....	....	....	....	2	1	1	8	0	66 30	Steamer Memphis, 17′ 6″, bound in, at 10.30 a. m. grounded on east side of channel, at Lower Cans.
	3	3.3	N.	4	N.NE.	3	10 40	....	....	....	....	2	1	....	10	0	.....	
	4	3.3	S.	2	S.	2	4 15	15½	2	17½	70	4	5	1	16	6	20	Ship Arcturus, 16′ 6″, bound out, at 2.45 p. m. grounded on Outer Lump; got off at 3.05 p. m.
	5	3.2	S.E.	2	S.E.	2	.....	....	....	....	....	4	6	....	18	4	.....	Steamer Memphis, 17′ 6″, passed in, at 5 a. m.
	6	3.1	S.E.	3	S.E.	3	45	....	....	....	....	7	4	1 1	19	0	50 24 00	Ship Advance, 19′, bound out, at 5.45 a. m. grounded at lower end of bar; got off at 6.35 a. m. Bark ——, 17′, bound out, at 11.30 a. m. grounded on west side of channel, below Can 5.
	7	2.9	S.E.		S.E	2	.....	....	....	....	....	5	3	....	17	0	.....	Bark —— got off at 11.30 a. m.

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Force.	12 m. Direction.	Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Feet.*	*h. m.*	
May 8	2.9	W.	7	S.	1	5 30	....	....	....	....	4	1	1	18 9	2 00	Ship City of Liverpool, 18′ 9″, bound out at 6.30 a. m., was 2 hours crossing bar.
9	3.1	N. W.	3	N. NE.	3	20	....	....	....	....	6	....	....	17 6	.....	
10	3.0	N. E.	1	E.	1	Delayed by accident to rudder.	16	2½	18½	70	5	3	....	18 0	.....	
11	3.1	N.	1	N. E.	1		14½	2	16½	80	1	3	....	18 6	.....	
12	3.1	N.	1	E.	2		....	....	....	....	8	1	1 1	15 0	2 00 62 40	Steamer Rita, 12′ 6″, bound in, at 1 a.m. grounded on east side of channel; got off and passed in at 3 p. m. Steamer Guillermo, 18′ 3″, bound out, at 12.20 p. m. grounded on west side of channel, at lower end of bar.
13	3.1	N.	1	N.	1		15½	2	17½	80	2	....	....	12 0	.....	
14	3.1	N.	1	N.	1		....	....	....	....	3	2	....	13 6	.....	
15	3.1	S. E.	2	S. E.	2		....	....	....	....	6	2	1	18 3	19 45	Steamer Guillermo, 18′ 3″, passed out at 1 30 p. m. Bark Tolomeo, 16′, bound in, at 6.15 p. m. grounded on west side of channel, above Lower Cana.
16	3.2	E.	2	E.	2		....	....	....	....	4	1	....	16 6	.....	Bark Tolomeo passed in at 2 p. m.
17	3.1	E.	2	E.	2		....	....	....	....	1	1	....	16 0	.....	
18	3.2	E.	1	E.	1	5 20	....	....	....	....	2	2	1	17 6	38 30	Ship Birmingham, 17′ 6″, bound out, at 11.30 a. m. grounded on west side of channel, below Can 5.
19	3.1	S. E.	2	S. E.	2	9 25	....	....	....	....	1	2	....	9 0	.....	
20	3.1	S. E.	2	S. E.	2	7 30	....	....	....	....	4	1	....	17 6	.....	Ship Birmingham, 17′ 6″, bound out, got off at 2 a. m.
21	3.1	S.	1	S.	1	.....	16	2	18	50	....	3	1	17 6	14 40	Steamer Hanover, 17′ 6″, bound out, at 3.40 p. m. grounded on west side of channel at Can 5.
22	3.1	S.	2	0	0	.....	....	....	....	....	2	2	....	18 0	.....	Steamer Hanover got off at 6.20 a. m.
23	3.1	S. E.	1	S. E.	1	6 20	....	....	....	....	1	4	....	18 0	.....	
24	3.2	0	0	E.	1	.....	15½	2½	18	60	8	4	....	17 6	.....	
25	3.2	E.	1	E.	1	6 15	....	....	....	....	2	1	....	14 0	.....	
26	3.3	0	0	E.	1	.....	....	....	....	....	1	4	1	18 6	17 00	Bark Almira, 18′, bound out, at 3 p. m. grounded on west side of channel, just above Lower Can.

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	27	3.3	0	0	0	0	.....	16	2½	18½	70	.....	1	.....	18	0	.....	Bark Almira got off at 8 a. m.
	28	3.4	0	0	N. E.	2	.....	.....	.....	.....	.....	1	2	.....	17	6	.....	
	29	3.3	0	0	E.	1	6 15	.....	.....	.....	.....	4	.....	.....	17	0	.....	
	30	3.4	0	0	0	0	.....	.....	.....	.....	.....	.....	3	.....	17	0	.....	
	31	3.2	S. SE.	2	S. SE.	2	.....	16	2½	18½	50	2	3	.....	16	6	.....	
June	1	3.3	S. E.	2	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	2	3.3	N. W.	5	N. E.	3	5 35	.....	.....	.....	.....	1	2	.....	15	6	.....	
	3	3.2	W.	2	N. W.	2	.....	16	2½	18½	50	3	3	1	16	6	4 00	Ship Her Majesty, 13′, bound in, at 6 p. m. grounded at lower end of bar; got off and passed in at 10 p. m.
	4	3.3	N. W.	1	N. W.	1	.....	.....	.....	.....	.....	1	1	.....	.....	.....	.....	
	5	3.3	N.	1	N. E.	1	.....	.....	.....	.....	.....	3	3	.....	18	0	.....	
	6	3.3	N. E.	1	N. E.	1	8 35	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	
	7	3.4	N. E.	1	E.	2	.....	16	2½	18½	60	.....	.....	1	.....	.....	21 30	Steamer Andean, 18′ 6″, bound out, at 6.30 a. m. grounded at lower end of bar.
	8	3.4	S. E.	3	S. E.	3	.....	.....	.....	.....	.....	2	13	.....	18	6	.....	Steamer Andean got off at 4 a.m. Dredge-boat McAlester left Southwest Pass for city at 3.35 p. m.
	9	3.7	S. E.	1	E.	1	.....	.....	.....	.....	.....	3	5	.....	.....	.....	.....	
	10	3.7	E.	1	N. E.	1	.....	.....	.....	.....	.....	3	2	.....	.....	.....	.....	
	11	3.5	N. E.	1	N. E.	1	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	
	12	3.7	S. W.	1	S. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	The dredge-boat Essayons arrived at Southwest Pass at 5.30 p. m., from New Orleans, after undergoing extensive repairs.
	13	3.6	S. W.	2	S. E.	2	.....	.....	.....	.....	.....	2	3	.....	16	6	.....	
	14	3.9	S. W.	2	S. W.	4	.....	.....	.....	.....	.....	.....	1	.....	16	0	.....	
	15	3.9	S. W.	2	W.	5	.....	15½	2½	17½	70	1	1	.....	16	6	.....	
	16	3.9	S. W.	5	S. W.	5	.....	.....	.....	.....	.....	1	3	.....	17	0	.....	
	17	3.9	S. W.	3	S. W.	3	6 00	16	2½	18½	70	.....	1	.....	17	9	.....	
	18	4.2	S. W.	5	S. W.	7	4 00	.....	.....	.....	.....	.....	1	1	13	0	17 00	Ship Uncle Felix, 18′, grounded on east side of channel at 12 m.
	19	4.1	S. W.	2	S. W.	2	11 00	.....	.....	.....	.....	2	2	.....	18	3	.....	Ship Uncle Felix got off and to sea at 5 a. m.
	20	4.3	S.	2	S.	2	13 00	.....	.....	.....	.....	.....	1	1	18	2	22 00	Ship Baden, 19′, bound out, grounded on west side of channel at 7 a. m.
	21	4.4	S. E.	4	S. E.	2	9 00	15½	2½	18	70	2	5	.....	19	0	.....	Ship Baden got off and to sea at 5 a. m.
	22	4.4	W.	1	W.	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	23	4.6	S. W.	1	S. W.	1	2 00	.....	.....	.....	.....	.....	.....	1	.....	.....	141 00	Steamer Muriel, 18′, bound out at 7 a. m., grounded.
	24	4.6	S. W.	3	S. W.	2	.....	15½	2½	17½	70	.....	1	.....	13	0	.....	
	25	4.7	S. W.	4	W.	3	.....	.....	.....	.....	.....	.....	2	.....	12	0	.....	
	26	4.8	S. W.	2	S. W.	3	10 00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	27	4.8	S.	3	S. E.	2	5 00	.....	.....	.....	.....	.....	2	.....	12	0	.....	
	28	4.8	S. W.	1	S. W.	5	.....	.....	.....	.....	.....	1	1	.....	8	0	.....	
	29	4.9	S.	1	S. E.	2	.....	.....	.....	.....	.....	.....	1	1	18	0	26 45	Steamer Muriel, 18′, got off and went to sea at 4 a. m. Steamer Haytien, 18′ 6″, grounded east side of channel at 7 a. m.; she got off and went to sea July 1, at 9.45 a. m.
	30	5.6	S.	1	S. E.	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Wind at S. W. Pass. 6 a. m. Force.	Wind at S. W. Pass. 12 m. Direction.	Wind at S. W. Pass. 12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Casualties at S. W. Pass. Greatest draught.	Casualties at S. W. Pass. Time of delay.	Remarks.
1875.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
Nov. 4	13.9	S. E.	4	S. E.	2	3 30	....	....	....	....	8	6	....	18 8	.....	
5	14.0	S. E.	5	S. E.	4	.....	....	....	....	....	5	1	....	18 6	.....	
6	13.7	N.	2	N.	4	.....	16	2	18	50	4	1	....	17 6	.....	
7	13.5	N. E.	5	N. E.	4	.....	....	....	....	....	2	1	....	17 0	.....	
8	13.7	N. W.	5	N. W.	4	.....	....	....	....	....	1	1	....	15 0	.....	
9	13.0	N. E.	6	E.	8	.....	....	....	....	....	2	1	....	19 6	.....	
10	14.0	N. W.	6	N. W.	7	.....	16	1½	17½	50	2	6	....	17 6	.....	
11	14.4	N. W.	2	N. W.	2	.....	....	....	....	....	2	5	....	17 6	.....	
12	14.7	W.	1	E.	2	.....	....	....	....	....	5	2	....	17 0	.....	
13	14.4	S.	2	S. E.	2	.....	16½	2½	18½	60	4	2	....	12 0	.....	
14	14.5	S. E.	4	E.	4	.....	....	....	....	....	2	4	....	18 6	.....	
15	14.7	S. W.	4	E.	5	.....	....	....	....	....	3	....	....	15 0	.....	
16	14.8	E.	1	S. W.	3	.....	....	....	....	....	2	1	....	18 2	.....	
17	14.6	N. W.	6	N. W.	6	4 00	16	2½	18½	60	4	6	....	18 0	.....	
18	14.5	S. E.	2	S. E.	4	.....	....	....	....	....	4	....	....	15 0	.....	
19	14.3	E.	1	S. E.	2	.....	....	....	....	....	2	2	....	18 8	.....	
20	14.3	E.	2	S. E.	3	.....	16	2½	18½	60	5	1	....	17 0	.....	
21	14.1	E.	1	S. E.	1	.....	....	....	....	....	2	3	1	18 6	10 00	Steamer Castilla, 18′ 6″, bound out, grounded on west side of channel, near Can 4, at 5 p. m.
22	13.9	S. E.	3	N. E.	4	.....	....	....	....	....	2	4	1	18 0	7 00	Steamer Castilla got off and went to sea at 3 a. m. Steamer Durham, 18′ 6″, bound out, at 10 a. m. grounded on west side of channel, near Cleopatra Buoy. Steamer Durham got off and went to sea at 5 p. m.
23	13.7	N. E.	4	S. E.	5	.....	....	....	....	....	4	2	....	18 6	.....	
24	13.5	E.	1	N.	5	.....	16½	1½	18	60	1	5	1 1	18 6	3 00 7 00	Steamer Paschal, 18′ 6″, bound out, at 9 a. m. grounded on west side of channel, near last buoy; got off and went to sea at 12 m. Steamer Texas, 18′ 6″, bound out, at 5 p. m. grounded on west side of channel, near last buoy; got off and went to sea at 12 p. m.
25	13.5	N. E.	7	N. E.	4	.....	....	....	....	....	4	....	....	18 6	.....	

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	26	13.3	S.	2	S.	1	.....	.....	.....	.....	.....	3	...	...	17	0	.....	
	27	13.5	E.	1	N.	2	.....	16½	2	18½	60	2	...	...	15	0	.....	
	28	13.4	N.E.	2	E.	2	.....	.....	.....	.....	.....	3	7	....	17	0	.....	
	29	13.0	N.E.	2	N.	2	.....	.....	.....	.....	.....	1	...	....	15	0	.....	
	30	12.6	N.E.	6	N.E.	7	.....	.....	.....	.....	.....	3	...	....	17	0	.....	
Dec.	1	12.9	N.E.	3	S.E.	1	.....	16½	2	18½	60	1	2	....	17	6	.....	
	2	12.8	N.E.	1	N.E.	1	.....	.....	.....	.....	.....	3	8	1	18	6	4 00	Steamer Mariner, 18′ 6″, bound out, at 5 p. m. grounded on west side of channel near lower can; got off and to sea at 9 p. m.
	3	12.6	N.E.	2	N.E.	2	.....	.....	.....	.....	.....	2	4	....	17	0	.....	
	4	11.9	N.E.	6	E.	7	.....	16	2½	18½	60	3	1	....	18	0	.....	Rough on bar.
	5	11.5	N.E.	3	N.E.	4	.....	.....	.....	.....	.....	1	4	....	18	0	.....	
	6	11.2	E.	2	E.	2	.....	.....	.....	.....	.....	2	1	....	18	6	.....	
	7	10.8	S.W.	7	S.W.	8	.....	.....	.....	.....	.....	.....	7	....	15	0	.....	
	8	10.7	W.	7	W.	8	.....	.....	.....	.....	.....	3	1	....	14	0	.....	Too rough to sound bar.
	9	10.8	W.NW.	1	N.	1	.....	.....	.....	.....	.....	3	4	....	18	0	.....	
	10	10.6	N.	1	0	0	.....	.....	.....	.....	.....	1	4	....	18	9	.....	
	11	10.5	S.SW.	1	N.W.	1	.....	16	2½	18½	60	3	4	1	18	0	5 00	Steamer Yazoo, bound in, at 7 a. m. disabled her machinery and grounded to the westward of Wreck Can; got off and passed in at 12 m.
	12	10.6	0	0	N.W.	1	.....	.....	.....	.....	.....	...	9	..	19	0	.....	
	13	10.7	N.W.	1	W.	1	.....	.....	.....	.....	.....	6	...	....	17	5	.....	
	14	10.7	N.NE.	2	N.NE.	2	1 45	.....	.....	.....	.....	5	3	....	17	6	.....	
	15	10.6	E.SE.	2	S.	2	3 15	16	2½	18½	60	4	3	1	19	3	6 00	Bark N. S., 13′, sailing in, at 7 a. m. grounded east of channel; got off and passed in at 1 p. m.
	16	10.8	S.W.	1	S.	1	.....	.....	.....	.....	.....	2	7	1	19	0	2 00	Steamer New Orleans, 19′, bound out at 5 p. m., was two hours crossing the bar.
														1			89 00	Ship Lizzie Burrill, 16′ 8″, bound out, at 11 p. m. grounded west of channel above Can 5.
	17	10.7	N.NW.	4	N.NW.	4	5 00	.....	.....	.....	.....	4	4	1	19	6	6 00	Steamer Yazoo, 19′ 6″, bound out at 4 p. m., was six hours crossing the bar.
	18	10.9	N.	3	N.NE.	3	5 00	16	1½	17½	60	6	2	....	17	6	.....	
	19	11.1	N.NE.	2	N.E.	2	.....	.....	.....	.....	.....	6	8	....	18	0	.....	
	20	11.2	E.	2	E.	2	.....	.....	.....	.....	.....	15	2	....	16	0	.....	
	21	11.1	E.SE.	2	E.SE.	2	.....	.....	.....	.....	.....	5	2	....	19	3	.....	Ship Lizzie Burrill got off bar at 4 p. m.
	22	11.2	0	0	E.SE.	2	.....	16	2	18	70	7	3	....	17	6	.....	
	23	11.2	S.E.	1	S.E.	2	.....	.....	.....	.....	.....	5	2	....	18	6	.....	
	24	11.1	S.E.	1	S.	2	.....	.....	.....	.....	.....	11	2	....	18	0	.....	
	25	10.9	S.SE.	2	S.SE.	2	.....	16	2½	18½	70	12	3	....	17	0	.....	
	26	10.6	S.SE.	1	S.SE.	1	.....	.....	.....	.....	.....	7	4	....	17	6	.....	
	27	10.5	S.SE.	2	S.SE.	2	.....	.....	.....	.....	.....	5	1	....	15	0	.....	
	28	10.4	S.E.	2	S.E.	3	.....	.....	.....	.....	.....	8	....	1	15	6	30 00	Ship Astoria, 18′ 5″, bound out, at 3 p. m. grounded on bar.
	29	10.3	S.	2	S	2	.....	16	2½	18½	70	6	2	....	18	5	.....	Ship Astoria got off bar at 9 p. m.
	30	10.3	E.	2	E.	2	3 45	.....	.....	.....	.....	4	13	1	18	7	28 00	Ship Bohemia, 18′ 8″, bound out, at 6 p. m. grounded on west side of channel.
	31	10.1	E.	4	E.	4	.....	.....	.....	.....	.....	9	3	...	18	8	.....	Ship Bohemia got off bar at 10 p. m.
1876.																		
Jan.	1	10.0	E.	4	E.SE.	4	.....	16	2	18	75	11	5	....	18	6	.....	
	2	10.2	N.W.	2	N.W.	2	.....	.....	.....	.....	.....	9	7	....	18	0	.....	
	3	10.1	N.	2	N.	2	4 10	.....	.....	.....	.....	9	2	1	13	0	12 00	Steamer Haytien, 18′, bound out, at 9 p. m. grounded on west side of channel.
	4	10.0	N.NE.	2	N.NE.	2	.....	.....	.....	.....	.....	9	5	....	18	0	.....	Steamer Haytien got off at 9 a. m.
	5	9.6	E.	2	E.SE.	2	.....	16	2	18	70	7	5	....	18	0	.....	

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	6 a. m. Force.	12 m. Direction.	12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
Jan. 6	9.2	N.	2	N.	2	.....	.....	.....	.....	.....	8	5	.....	19 3	.....	
7	8.6	N.	1	N.	1	.....	.....	.....	.....	.....	6	9	.....	19 6	.....	
8	8.2	E. SE.	1	E. SE.	1	.....	16	2½	18½	60	9	4	1	19 0	3 15	Steamer Vanguard, 17′, bound in, at 7.30 a. m. grounded on east side of channel; got off and passed in at 10.45 a. m.
9	7.7	S. E.	2	S.	2	3 45	16	3	19	60	8	2	1	18 11	2 30	Ship J. A. Thompson, 18′ 11″, bound out, at 4 p. m. grounded on west side of channel; got off and went to sea at 6.30 p. m.
10	7.2	N.	3	N.	3	4 10	.....	.....	.....	.....	6	4	.....	16 0	.....	
11	6.9	N.	4	N.	4	5 20	.....	.....	.....	.....	6	2	.....	15 0	.....	
12	6.9	N.	4	N. NE.	2	4 45	.....	.....	.....	.....	3	2	1	18 0	8 00	Steamer George W. Elder, 18′, bound out, at 2 p. m. grounded on west side of channel; got off and to sea at 10 p. m.
													1		8 00	Ship Merom, 17′ 6″, bound out, at 2 p. m. grounded to the westward about Wreck Can; she got to sea at 10 p. m.
13	6.5	N. E.	4	N. E.	4	4 50	.....	.....	.....	.....	2	5	1	19 6	9 00	Ship Birmingham, 14′, bound in, at 3 p. m. grounded east of channel; got off and passed in at 12 p. m.
													1		5 00	Steamer Mississippi, 19′ 6″, bound out, at 6 p. m. grounded on bar; got off and to sea at 11 p. m.
14	6.3	N. E.	3	N. E.	3	5 00	.....	.....	.....	.....	9	2	.....	16 0	.....	
15	6.1	E.	2	E.	3	.....	16	2½	18½	75	15	4	.....	18 6	.....	
16	5.8	E.	2	E.	3	.....	.....	.....	.....	.....	10	3	.....	16 0	.....	
17	5.6	S. E.	3	S. E.	2	.....	.....	.....	.....	.....	6	2	.....	17 6	.....	
18	5.6	S. SE.	3	S.	1	.....	.....	.....	.....	.....	4	1	.....	16 0	.....	
19	5.6	W.	2	W. NW.	2	.....	16	2	18	60	7	7	1	18 0	6 00	Steamer Barraindale, 18′, bound out, at 3.30 p. m. grounded on west side of channel; got off and sailed at 9.30 p. m.
20	5.6	N.	3	N. E.	2	2 40	.....	.....	.....	.....	6	10	1	19 0	2 00	Bark Georgiana, 18′ 6″, bound out at 4 p. m., was two hours crossing bar.
21	5.7	E.	2	E.	3	3 20	.....	.....	.....	.....	4	3	.....	18 6	.....	
22	5.6	S. E.	2	S. E.	2	.....	16	2½	18½	75	6	2	.....	18 6	.....	
23	5.9	S. E.	2	S. E.	2	.....	.....	.....	.....	.....	3	5	...	18 6	.....	
24	5.9	0	0	N. W.	1	.....	.....	.....	.....	.....	.....	1	.....	8 0	.....	

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	25	5.8	N. E.	1	N. E.	1	.....	...	...	...	...	1	...	...	13	0	.....	
	26	5.9	0	0	N. E.	2	.....	15½	2½	17½	90	4	9	...	17	0	.....	Dense fog, preventing work.
	27	5.7	S. E.	3	S. E.	3	7 20	....	....	....	....	4	3	1	18	0	117 00	Ship Success, 18′, bound out, at 3 p. m. grounded on west side of channel, near Cleopatra Buoy.
														1			3 00	Bark Porvener, 13′, bound in, at 10.30 a. m. grounded on east side of channel above Lower Cans; got off and passed in at 1.30 p. m.
	28	5.7	S. E.	3	S. SW.	4	7 05	....	....	....	....	3	3	1	17	0	4 45	Steamer Oberon, 17′, bound out, at 3.30 p. m. grounded at lower end of channel; got off and sailed at 8.15 p. m.
	29	5.5	N. W.	2	N. W.	5	1 00	...	....	....	....	1	1	....	4	0	.....	
	30	5.4	N.	4	N.	4	5 10	....	....	....	....	1	1	....	14	0	.....	
	31	5.3	N. E.	1	N. E.	1	.....	....	....	....	....	2	1	....	19	0	.....	
Feb.	1	5.1	S.	4	W.	3	3 00	....	....	....	....	8	1	....	16	6	.....	Ship Success was towed inside at 12 m; rough bar.
	2	5.1	N.	5	N.	3	6 45	....	....	....	....	3	16	....	16	6	.....	
	3	5.3	E. SE.	2	E. SE.	2	6 45	15½	2½	18	60	6	11	1	16	6	1 20	Ship Elizabeth Dougall 16′ 3″, bound out, at 1.40 p. m. grounded on east side of channel at Lower Cans; got off at 3 p. m.
	4	5.4	W.	6	N. W.	5	4 45	....	....	....	....	2	2	....	16	0	.....	
	5	5.3	N.	1	N.	1	9 20	15	2	17	50	4	5	1	17	0	1 00	Bark Ocean, 16′ 6″, bound out, at 2 30 p. m. grounded on west side of channel, near Lower Cans; got off and sailed at 3.30 p. m.
														1			2 00	Ship Paul Boynton, 18′, bound out, at 3.15 p. m. grounded on west side of channel, above Lower Cans; got off at 5.15 p. m.
	6	5.4	E.	2	E.	2	8 15	....	....	....	....	8	11	1	18	6	55	Steamer Bolivar, 18′, bound out, at 4 p. m. grounded just above Lower Cans; got off at 4.55 p. m.
														1			30	Steamer Frankfort, 18′ 6″, bound out, at 6 p. m. was 30 minutes crossing bar.
	7	5.1	E.	2	N. E.	3	7 10	....	....	....	....	6	6	1	18	10	20	Steamer Guillermo, 18′ 10″, bound out, at 4.50 p. m. grounded on west side of channel; got off and sailed at 5.10 p. m.
	8	5.0	E. NE.	1	N.NE.	1	.....	....	....	....	....	4	1	....	15	6	.....	
	9	4.9	N.NE.	1	E.	2	7 20	15½	2½	18	60	7	3	1	19	0	55	Ship Adolphus, 19′, bound out, at 4.45 p. m. grounded on outside East Mud-Lump; got off at 5.40 p. m.; thick fog.
	10	4.8	S. E.	1	S. E.	1	6 55	....	....	....	....	2	2	1	16	0	45	Ship Lake Ontario, 16′, bound in, at 3 p. m. grounded on west side of channel, at Lower Cans; got off and passed in at 3.45 p. m.
	11	4.7	S. E.	1	S. E.	1	.....	....	....	....	....	3	3	1	18	0	n't kn'n	Steamer Tappahannock, 11′ 6″, bound out; dense fog; grounded east of channel, above East Mud-Lump; survey station.
	12	4.7	S. E.	1	S.	1	8 50	....	....	....	....	4	....	....	15	0	.....	
	13	4.6	S.	2	S. SE.	3	9 50	16	2	18	70	16	5	1	18	0	2 50	Ship Union, 13′ 6″, bound in, at 9.30 a. m. grounded on west side of channel, at Lower Cans; towed inside at 11.20 a. m.
														1			45	Bark Vesuvio, 13′, bound out, at 2.30 p. m. grounded on east side of channel, above Lower Cans; got off at 3.15 p. m.; light fog.
																		Steamer Tappahannock got off and sailed at 6 a. m.
														1			6 15	Schooner Daisy E. Parkhurst, 12′, sailing out, at 9 a. m. grounded at lower end of bar; got off at 3.15 p. m.
	14	4.5	N. NW.	2	N. NW.	1	.....	....	....	....	....	2	17	1	17	6	3 40	Bark Australia, 15′ 6″, bound out, at 5.20 p. m. grounded on west side of channel at lower end of bar; got off about 9 p. m.
														1			19 30	Bark Ruby, 16′, bound out, at 1 p. m. grounded on east side of channel, at lower end of bar.
																		Bark Ruby got off and sailed at 8.30 a. m.
														1			25	Steamer Memphis, 16′ 6′, bound in, at 9.35 a. m. grounded at lower end of bar, on west side of channel; got off and passed in at 10 a. m.
	15	4.6	N. NW.	3	N. NW.	3	7 25	....	....	....	....	3	4	1	16	6	2 35	Bark Sleipner, 15′, bound out, at 4.25 p. m. grounded on west side of channel, just above Lower Cans; got off and sailed at 7 p. m.

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Wind at S. W. Pass. 6 a. m. Force.	Wind at S. W. Pass. 12 m. Direction.	Wind at S. W. Pass. 12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Casualties at S. W. Pass. Greatest draught.	Casualties at S. W. Pass. Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	*h. m.*	
													1		6 40	Ship Zelandia, 17′, bound out, at 10.20 a. m. grounded on east side of channel, at Lower Cans; got off at 5 p. m.
Feb. 16	4.7	N. W.	1	0	0	2 55	16	2	18	70	1	6	1	17 0	24 50	Bark Embla, 14′, bound out, at 10.20 a. m. grounded on west side of channel, at Lower Cans.
													1		16 15	Bark Albert, 16′, bound out, at 6 p. m. grounded on east side of channel, at Lower Cans.
																Bark Embla got off and sailed at 11.10 a. m. Bark Albert got off and sailed at 10.15 a. m.
17	4.6	N.	2	E.NE.	2	2 05	....	....	....	....	5	6	1	16 0	2 15	Steamer Margaret, 13′, bound out, at 6.30 a. m., without pilot, grounded on west side of channel, at Lower Cans; got off and sailed at 8.45 a. m.
													1		75 15	Steamer San Marcas, 18′ 3″, bound out, at 2 p. m. grounded in channel, just below Can 5.
18	4.6	N.NE.	4	N.NE.	4	2 45	....	....	....	....	2	1	1	9 0	55 25	Steamer Hudson, 15′, bound in, at 9.35 a. m. grounded just above Lower Cans, and swung across the channel.
19	4.7	N. E.	2	N. E.	2	.....	15½	2½	18	60	2	1	....	11 6	.....	Dredge-boat McAlester collided with San Marcas, breaking two of her upper plates.
20	4.6	E. NE.	2	E. NE.	2	.....	....	....	....	....	5	5	....	18 3	.....	Steamer San Marcas got off and to sea at 5.15 p. m. Steamer Hudson got off and passed in at 3 p. m.
21	4.6	S. E.	2	S. E.	2	2 10	....	....	....	....	1	4	....	14 0	.....	
22	4.5	N. E.	4	N. NE.	3	.....	....	....	....	....	4	10	....	18 3	.....	
23	4.6	N.	3	N. NW.	3	4 50	15½	2½	18	75	....	10	1	18 0	55	Ship Gen. Shepley, 15′ 6″, bound out, at 11.45 a. m. grounded on east side of channel, below Can 5; got off and sailed at 12.40 p. m.
													1		1 00	Ship John Watts, 17′, bound out, at 1 p. m. grounded at lower end of bar; got off and sailed at 2 p. m.
24	4.5	N.	2	N. NE.	2	4 05	....	....	....	....	2	11	1	18 3	2 00	Bark Tilde, 18′, bound out, at 5 p. m. grounded at lower end of bar; got off and sailed at 7 p. m.
													1		3 20	Ship David Malcomson, 18′ 3″, bound out, at 2 p. m. grounded at lower end of bar, on west side of channel; got off and sailed at 5.20 p. m.

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	25	4.4	N.	3	N. NW.	3	.....	....	....	....	....	4	8	1	17	8	22 30	Ship B. F. Metcalf, 16′ 8″, bound out, at 6 p. m. grounded on outer East Mud-Lump.
														1			21 20	Bark Vanguard, 18′ 10″, bound out, at 8 p. m. grounded on east side of channel, at Lower Can.
	26	4.4	E.	3	E.	3	5 00	15½	2	17½	75	2	3	....	18	10	.....	Ship B. F. Metcalf got off at 4.30 p. m. Bark Vanguard got off at 5.20 p. m.
	27	4.1	E. SE.	2	S. SW.	2	.....	....	....	....	....	3	11	1	17	0	14 4	Steamer Muriel, 17′, bound out, at 3 p. m. grounded on west side of channel, just above Can 5.
	28	4.1	E.	1	N. NE.	2	2 30	....	....	....	....	1	4	....	18	0	.....	
	29	4.2	N. E.	2	N. E.	2	.....	....	....	....	....	3	11	....	18	8	.....	
Mar.	1	4.1	S. E.	1	S. E.	1	.....	16	2	18	80	1	....	....	16	0	.....	
	2	4.3	W. NW.	2	N. NW.	3	.....	....	....	....	....	2	5	1	16	8	53 00	Ship Ryerson, 18′, bound out, at 8.30 a. m. grounded on west side of channel, below Can 5.
	3	4.0	N. E.	4	N. E.	3	4 10	....	....	....	....	....	1	....	....	....	.....	
	4	4.0	E.	2	E.	2	4 50	15½	2½	18	60	3	13	....	17	6	.....	Steamer Muriel got off and sailed at 3 p. m.
	5	4.2	E.	2	E. SE.	2	1 15	....	....	....	....	2	3	1	19	3	102 00	Ship Ryerson passed out at 1.30 p. m. Ship Success, 18′, bound out, at 4 p. m. grounded west of channel, at lower end of bar.
	6	4.0	S. E.	5	S. E.	4	.....	....	....	....	....	2	....	....	14	0	.....	
	7	4.0	N. W.	3	W.	2	6 00	....	....	....	....	8	8	....	15	6	.....	
	8	4.2	N.	2	E.	2	9 00	15	2½	17½	50	4	9	....	17	0	.....	
	9	4.1	E.	2	E.	2	4 35	....	....	....	....	6	11	1	18	6	1 00	Bark Poolsear, 18′ 2″, bound out, at 1 p. m. grounded at lower end of bar; got off at 2 p. m.
														1			30	Steamer Andean, 18′ 6″, bound out, at 4.30 p. m. stuck 30 minutes on outside lump.
														..			.....	Ship Success, 18′, got off and passed out at 10 p. m.
	10	3.9	S. E.	2	S. E.	2	2 40	....	....	....	....	4	8	1	19	4	3 30	Ship Agnes Sutherland, 19′ 4″, bound out, at 3 p. m. grounded at lower end of bar; got off at 6.30 p. m.
	11	3.9	E. SE.	2	S. E.	2	.....	....	....	....	....	2	....	1	15	0	17 00	Rough bar. Ship Raphael, 19′, bound out, at 4.20 p. m. grounded on west side of channel, just above Lower Cans.
																		Ship Raphael got off and passed out at 9.20 a. m.
	12	3.7	N. NE.	2	S. E.	1	8 25	....	....	....	....	3	6	1	19	0	2 40	Ship Prince Leopold, 18′ 10″, bound out, at 1 p. m. grounded on west side of channel, below Can 5; got off and sailed at 3.40 p. m.
	13	3.8	N.	3	E.	3	9 25	15½	2½	18	60	2	11	1	18	7	2 30	Ship John Mann, 18′ 7″, bound out, at 7.45 a. m. grounded at lower end of bar; she got off at 10.15 a. m.
	14	3.8	E.	2	E.	2	5 35	....	....	....	....	1	8	....	18	6	.....	
	15	3.7	E. SE.	2	E. SE.	4	.....	16	2½	18½	80	6	3	....	19	0	.....	
	16	3.8	W.	2	W.	2	5 10	....	....	....	....	2	9	....	17	0	.....	
	17	3.8	N. E.	1	N. E.	1	10 55	....	....	....	....	6	3	....	18	6	.....	
	18	4.0	N.	4	N.	4	.....	16	2	18	70	3	....	1	13	0	30 00	Steamer Alice, 14′ 6″, bound in, at 12.10 a. m. grounded on west side of channel, above Lower Cans.
	19	3.9	E.	5	E.	7	.....	....	....	....	....	2	1	....	16	6	.....	
	20	4.0	W.	4	W.	4	.....	....	....	....	....	1	1	....	14	6	.....	Steamer Alice, 14′ 6″, got off and passed in at 6 a. m.
	21	4.1	N. W.	3	N. W.	3	11 00	....	....	....	....	....	10	1	17	0	2 30	Steamer Fire Queen, 16′, grounded at lower end of bar, on west side of channel; got off and sailed at 9.30 a. m.
														1			23 45	Ship Mataura, 18′, bound out, at 5.15 p. m. grounded on east side of channel, at Lower Cans.
	22	4.2	N.	1	N. E.	2	10 10	16	2½	18½	60	3	4	....	18	0	.....	Ship Mataura got off and went to sea at 5 p. m.
	23	4.0	E.	3	S. E.	4	3 40	....	....	....	....	4	9	1	19	4	1 15	Ship Prince Eugene, 19′ 4″, bound out, at 4 p. m. grounded on west side of channel; got off at 5.15 p. m.
														1			23 30	Ship Adept, 19′ 2″, bound out, at 6.30 p. m. grounded on east side of channel, above Lower Can.

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	Force.	12 m. Direction.	Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1876.	*Feet.*					h. m.	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft. in.*	h. m.	
Mar. 24	3.6	S.	4	N.W.	9	6 20	....	....	....	....	5	1	1	19 2	61 30	Ship Adept got off and sailed at 6 p. m. Steamer Mississippi, 18′ 9″, bound out, at 7 p. m. grounded at lower end of bar, on east side of channel.
25	3.8	W.	2	N.	1	11 40	15½	2	17½	60	1	....	....	10 0	.....	
26	3.8	S. W.	1	S. SW.	2	8 30	....	....	....	....	4	....	1	16 0	1 05	Steamer Charles W. Lord, 13′ 6″, bound in, at 9.30 a. m. grounded west of channel; got off and passed in at 10.35 a. m.
													1		10 00	Brig Flora Goodale, about 13′, bound out, at 1 p. m. grounded west of Lower West Can Buoy; got off at 11 p. m.
27	3.6	S. E.	3	S. E.	3	.....	....	....	....	....	3	8	....	18 9	.....	Steamer Mississippi, 18′ 9″, got off and went to sea at 8.30 a. m.
28	3.6	W.	5	W.	5	.....	....	....	....	....	....	2	....	10 0	.....	
29	3.7	N. NW.	2	N.	1	4 40	16	2½	18½	60	3	14	1	18 0	1 50	Bark Osterlide, 16′, bound out, at 7 a. m. grounded on west side of channel, at Cleopatra Buoy; got off and sailed at 8.50 a. m.
													1		2 10	Bark Orina, 17′ 6″, bound out, at 12.30 p. m. grounded on west side of channel, above Lower Can; got off at 2.40 p. m.
													1		9 45	Bark Dominico Lanata, 15′, bound out, at 9.15 a. m. grounded on west side of channel, at Lower Can.
30	3.8	0	0	S. E.	1	8 20	....	....	....	....	....	9	....	17 0	.....	Bark Dominico Lanata, 15′, got off and sailed at 7 a. m.
31	3.9	E.	2	E. SE.	3	7 00	....	....	....	....	4	7	....	18 0	....	
Apr. 1	3.7	E. SE.	3	E. SE.	3	.....	....	....	....	....	2	1	....	16 0	.....	Rough bar; foggy.
2	3.5	S. SE.	2	S. SE.	2	.....	16	2½	18½	60	2	....	....	10 0	.....	Thick fog.
3	3.6	W.	2	W.	2	2 05	....	....	....	....	5	8	1	18 0	35	Ship Adriana, 18′, bound out at 1.45 p. m., was 35 minutes crossing the bar.
4	3.9	W.	1	S. W.	1	.....	....	....	....	....	1	....	1	17 6	46 00	Steamer Texas, 17′ 6″, bound in, at 7 a. m. grounded on east side of channel at lower end of bar.
5	4.0	S. E.	2	S. E.	2	7 40	16	2	18	40	4	4	1	17 0	24 25	Bark Virtuosa, 17′, bound out, at 4.35 p. m. grounded on east side of channel, at lower end of bar.
6	3.9	E.	3	N. E.	3	6 00	...	....	....	....	3	5	....	17 6	.....	Steamer Texas, 17′ 6″, passed in at 5 p. m. Bark Virtuosa, 17′, passed out at 5 p. m.

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	7	3.7	N. E.	2	E.	2	10 25	....	....	....	....	1	3	....	16	6	.....	
	8	3.7	W.	3	W.	3	.....	....	....	....	....	3	5	1	18	5	1 00	Rough bar. Steamer Dhoolia 18′ 5″, bound out at 7.30 a. m., was one hour crossing the bar.
	9	3.7	N.	1	E.	2	.....	16	2½	18½	90	6	8	1 1	18	0	40 1 00	Bark Siberia, 18′, bound out at 8.20 a. m., was 40 minutes crossing the bar. Ship D. W. Chapman, 17′, bound out, at 11.20 a. m. grounded on Outer Lump; got off at 12.20 p. m.
	10	3.6	N. E.	1	E.	2	5 25	....	....	....	....	1	3	1	18	6	2 00	Ship Thornhill, 18′ 6″, bound out, at 7.50 a. m. grounded at lower end of bar; got off at 9.50 a. m.
	11	3.5	E.	2	E.	2	.....	....	....	....	....	2	1	....	15	0	.....	
	12	3.7	S. E.	2	S. E.	2	.....	....	....	....	....	3	2	....	18	0	.....	Foggy; rough bar.
	13	3.5	S. E.	3	S. E.	3	.....	....	....	....	....	2	3	1	17	0	1 15	Steamer Frankfort, 17′, bound in, at 3.30 p. m. grounded on east side of channel, above Lower Cans; passed in at 4.45 p. m.
	14	3.5	N. W.	4	N. W.	3	5 00	....	....	....	....	1	6	1	16	0	23 00	Ship Wm. Douglas, 18′, bound out, at 12.30 p. m. grounded on east side of channel.
																	.....	Ship Wm. Douglas, 18′, bound out, got off bar and went to sea at 11.30 a.m.
	15	3.6	N.	2	N. NE.	2	3 20	16	2	18	100	2	9	1 1	18	2	1 05 1 35	Ship Westfield, 18′ 2″, bound out, at 12.30 p. m. grounded on west side of channel; got off at 1.35 p. m. Ship Sam Scholfield, 18′, bound out, at 2.15 p. m. grounded at first spar below Can 5; got off at 3.50 p. m.
	16	4.0	S. W.	1	S. W.	1	.....	....	....	....	....	1	6	....	18	9	.....	
	17	4.0	W.	3	W.	3	.....	....	....	....	....	3	....	....	14	0	.....	
	18	3.9	S.	2	N. E.	2	5 45	....	....	....	....	1	5	....	16	6	.....	
	19	3.9	S. E.	2	E.	2	10 20	16	2	18	60	2	6	1	17	0	15	Bark Bertha, 17′, bound out, at 10.30 a. m. grounded on east side of channel, at Can 5; got off at 10.45 a. m.
	20	3.8	S. E.	2	E.	2	7 30	....	....	....	....	3	3	....	18	0	.....	
	21	3.7	N. E.	2	N. E.	2	.....	....	....	....	....	3	1	....	15	0	.....	
	22	3.5	N. E.	1	N. E.	1	.....	....	....	....	....	2	....	1	18	0	24 15	Bark Brothers and Sisters, 18′, bound out, at 5.30 a. m. grounded at lower end of bar, on west side of channel.
	23	3.6	S. E.	2	S. E.	1	3 45	16	2½	18½	80	5	5	....	18	0	.....	Bark Brothers and Sisters, 18′, bound out, got off bar at 5.45 a. m.
	24	3.3	0	0	S.	1	.....	....	....	....	....	2	4	1	18	7	21 30	Ship City of Richmond, 17′, bound out, at 12 m. grounded on east side of channel.
	25	3.3	N. W.	3	N. W.	3	.....	....	....	....	....	....	6	....	17	0	.....	Ship City of Richmond, 17′, got off at 9.30 a. m.
	26	3.4	N. E.	2	N. E.	2	7 00	16	2½	18½	60	....	4	1	18	0	21 45	Ship N. Mosher, 18′ 7″, bound out, at 9. a. m. grounded on west side of channel.
	27	3.2	S. E.	2	S. E.	2	3 00	....	....	....	....	1	4	1	18	7	17 00	Ship N. Mosher, 18′ 7″, bound out, got off and sailed at 6.45 a. m. Steamer Hudson, 17′ 6″, bound out, got off and went to sea at 8 a. m.
	28	3.1	S.	2	0	0	.....	....	....	....	....	2	10	....	18	2	.....	
	29	3.2	N.	1	N. E.	1	4 35	16	2	18	60	....	....	....	....	....	.....	
	30	3.0	0	0	S.	1	.....	....	....	....	....	5	4	....	18	0	.....	
May	1	3.3	S.	2	S.	2	.....	....	....	....	....	4	1	....	15	0	.....	
	2	3.1	S. W.	3	S. W.	4	.....	....	....	....	....	2	1	1	8	0	66 30	Steamer Memphis, 17′ 6″, bound in, at 10.30 a. m. grounded on east side of channel, at Lower Cans.
	3	3.3	N.	4	N. NE.	3	10 40	....	....	....	....	2	1	....	10	0	.....	
	4	3.3	S.	2	S.	2	4 15	15½	2	17½	70	4	5	1	16	6	20	Ship Arcturus, 16′ 6″, bound out, at 2.45 p. m. grounded on Outer Lump; got off at 3.05 p. m.
	5	3.2	S. E.	2	S. E.	2	.....	....	....	....	....	4	6	....	18	4	.....	Steamer Memphis, 17′ 6″, passed in, at 5 a. m.
	6	3.1	S. E.	3	S. E.	3	45	....	....	....	....	7	4	1 1	19	0	50 24 00	Ship Advance, 19′, bound out, at 5.45 a. m. grounded at lower end of bar; got off at 6.35 a. m. Bark ——, 17′, bound out, at 11.30 a. m. grounded on west side of channel, below Can 5.
	7	2.9	S. E.		S. E	2	.....	....	....	....	....	5	3	....	17	0	.....	Bark —— got off at 11.30 a. m.

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Tabular statement to accompany annual report on the improvement of the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high-water of 1874. Gauge foot of Canal street.	Wind at S. W. Pass. 6 a. m. Direction.	6 a. m. Force.	12 m. Direction.	12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low-tide.	Height of high-tide above mean low-tide.	Total depth of channel at high-tide.	Least width at mean low-tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at S. W. Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Feet.*	*h. m.*	
May 8	2.9	W.	7	S.	1	5 30	....	....	....	....	4	1	1	18 9	2 00	Ship City of Liverpool, 18′ 9″, bound out at 6.30 a. m., was 2 hours crossing bar.
9	3.1	N. W.	3	N. NE.	3	20	....	....	....	....	6	....	....	17 6	.....	
10	3.0	N. E.	1	E.	1		16	2½	18½	70	5	3	....	18 0	.....	
11	3.1	N.	1	N. E.	1		14½	2	16½	80	1	3	....	18 6	.....	
12	3.1	N.	1	E.	2	Delayed by accident to rudder.	....	....	....	....	8	1	1 1	15 0	2 00 62 40	Steamer Rita, 12′ 6″, bound in, at 1 a.m. grounded on east side of channel; got off and passed in at 3 p. m. Steamer Guillermo, 18′ 3″, bound out, at 12.20 p. m. grounded on west side of channel, at lower end of bar.
13	3.1	N.	1	N.	1		15½	2	17½	80	2	....	....	12 0	.....	
14	3.1	N.	1	N.	1		....	....	....	....	3	2	....	13 6	.....	
15	3.1	S. E.	2	S. E.	2		....	....	....	....	6	2	1	18 3	19 45	Steamer Guillermo, 18′ 3″, passed out at 1.30 p. m. Bark Tolomeo, 16′, bound in, at 6.15 p. m. grounded on west side of channel, above Lower Cans.
16	3.2	E.	2	E.	2		....	....	....	....	4	1	....	16 6	.....	Bark Tolomeo passed in at 2 p. m.
17	3.1	E.	2	E.	2		....	....	....	....	1	1	....	16 0	.....	
18	3.2	E.	1	E.	1	5 20	....	....	....	....	2	2	1	17 6	38 30	Ship Birmingham, 17′ 6″, bound out, at 11.30 a. m. grounded on west side of channel, below Can 5.
19	3.1	S. E.	2	S. E.	2	9 25	....	....	....	....	1	2	....	9 0	.....	
20	3.1	S. E.	2	S. E.	2	7 30	....	....	....	....	4	1	....	17 6	.....	Ship Birmingham, 17′ 6″, bound out, got off at 2 a. m.
21	3.1	S.	1	S.	1	.....	16	2	18	50	....	3	1	17 6	14 40	Steamer Hanover, 17′ 6″, bound out, at 3.40 p. m. grounded on west side of channel at Can 5.
22	3.1	S.	2	0	0	.....	....	....	....	....	2	2	....	18 0	.....	Steamer Hanover got off at 6.20 a. m.
23	3.1	S. E.	1	S. E.	1	6 20	....	....	....	....	1	4	....	18 0	.....	
24	3.2	0	0	E.	1	.....	15½	2½	18	60	8	4	....	17 6	.....	
25	3.2	E.	1	E.	1	6 15	....	....	....	....	2	1	....	14 0	.....	
26	3.3	0	0	E.	1	.....	....	....	....	....	1	4	1	18 6	17 00	Bark Almira, 18′, bound out, at 3 p. m. grounded on west side of channel, just above Lower Can.

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	27	3.3	0	0	0	0	.....	16	2½	18½	70	....	1	....	18	0	.....	Bark Almira got off at 8 a. m.
	28	3.4	0	0	N. E.	2	.....	....	....	....	....	1	2	....	17	6	.....	
	29	3.3	0	0	E.	1	6 15	....	....	....	....	4	....	....	17	0	.....	
	30	3.4	0	0	0	0	.....	....	....	....	....	....	3	....	17	0	.....	
	31	3.2	S. SE.	2	S. SE.	2	.....	16	2½	18½	50	2	3	....	16	6	.....	
June	1	3.3	S. E.	2	S. E.	2	.....	....	....	....	....	....	....	....	....	....	.....	
	2	3.3	N. W.	5	N. E.	3	5 35	....	....	....	....	1	2	....	15	6	.....	
	3	3.2	W.	2	N. W.	2	.....	16	2½	18½	50	3	3	1	16	6	4 00	Ship Her Majesty, 13′, bound in, at 6 p. m. grounded at lower end of bar; got off and passed in at 10 p. m.
	4	3.3	N. W.	1	N. W.	1	.....	....	....	....	....	1	1	....	....	....	.....	
	5	3.3	N.	1	N. E.	1	.....	....	....	....	....	3	3	....	18	0	.....	
	6	3.3	N. E.	1	N. E.	1	8 35	....	....	....	....	....	1	....	....	....	.....	
	7	3.4	N. E.	1	E.	2	.....	16	2½	18½	60	....	....	1	....	....	21 30	Steamer Andean, 18′ 6″, bound out, at 6.30 a. m. grounded at lower end of bar.
	8	3.4	S. E.	3	S. E.	3	.....	....	....	....	....	2	13	....	18	6	.....	Steamer Andean got off at 4 a.m. Dredge-boat McAlester left South-west Pass for city at 3.35 p. m.
	9	3.7	S. E.	1	E.	1	.....	....	....	....	....	3	5	....	....	....	.....	
	10	3.7	E.	1	N. E.	1	.....	....	....	....	....	3	2	....	....	....	.....	
	11	3.5	N. E.	1	N. E.	1	.....	....	....	....	....	....	1	....	....	....	.....	
	12	3.7	S. W.	1	S. E.	2	.....	....	....	....	....	....	....	....	....	....	.....	The dredge-boat Essayons arrived at Southwest Pass at 5.30 p. m., from New Orleans, after undergoing extensive repairs.
	13	3.6	S. W.	2	S. E.	2	.....	....	....	....	....	2	3	....	16	6	.....	
	14	3.9	S. W.	2	S. W.	4	.....	....	....	....	....	....	1	....	16	0	.....	
	15	3.9	S. W.	2	W.	5	.....	15½	2½	17½	70	1	1	....	16	6	.....	
	16	3.9	S. W.	5	S. W.	5	.....	....	....	....	....	1	3	....	17	0	.....	
	17	3.9	S. W.	3	S. W.	3	6 00	16	2½	18½	70	....	1	....	17	9	.....	
	18	4.2	S. W.	5	S. W.	7	4 00	....	....	....	....	....	1	1	13	0	17 00	Ship Oncle Felix, 18′, grounded on east side of channel at 12 m.
	19	4.1	S. W.	2	S. W.	2	11 00	....	....	....	....	2	2	....	18	3	.....	Ship Oncle Felix got off and to sea at 5 a. m.
	20	4.3	S.	2	S.	2	13 00	....	....	....	....	....	1	1	18	2	22 00	Ship Baden, 19′, bound out, grounded on west side of channel at 7 a. m.
	21	4.4	S. E.	4	S. E.	2	9 00	15½	2½	18	70	2	5	....	19	0	.....	Ship Baden got off and to sea at 5 a. m.
	22	4.4	W.	1	W.	1	.....	....	....	....	....	....	....	....	....	....	.....	
	23	4.6	S. W.	1	S. W.	1	2 00	....	....	....	....	....	....	1	....	....	141 00	Steamer Muriel, 18′, bound out at 7 a. m., grounded.
	24	4.6	S. W.	3	S. W.	2	.....	15½	2½	17½	70	....	1	....	13	0	.....	
	25	4.7	S. W.	4	W.	3	.....	....	....	....	....	....	2	....	12	0	.....	
	26	4.8	S. W.	2	S. W.	3	10 00	....	....	....	....	....	....	....	....	....	.....	
	27	4.8	S.	3	S. E.	2	5 00	....	....	....	....	....	2	....	12	0	.....	
	28	4.8	S. W.	1	S. W.	5	.....	....	....	....	....	1	1	....	8	0	.....	
	29	4.9	S.	1	S. E.	2	.....	....	....	....	....	....	1	1	18	0	26 45	Steamer Muriel, 18′, got off and went to sea at 4 a. m. Steamer Haytien, 18′ 6″, grounded east side of channel at 7 a. m.; she got off and went to sea July 1, at 9.45 a. m.
	30	5.6	S.	1	S. E.	1	.....	....	....	....	....	....	....	....	....	....	.....	

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J 2.

IMPROVING HARBOR AT GALVESTON, TEXAS.

The progress made in this work during the year and its history will be partially shown by extracts from the monthly reports of the assistant in superintendence.

On the 3d of August this office reported as follows for July:

* * * * * * *

The scow for the transportation of gabions was completed, and the arrival of the steam-tug enabled us to make a trial of it in sinking gabions, although the condition of the tide was rather unfavorable. It was found that the scow answered the purpose for which it was intended admirably.

Twelve 6-foot gabions and four 12-foot gabions were sunk. Much more might have been accomplished had the tide been less swift, and the character of the bottom been favorable for the action of the sand-pump and the placing of piles.

The tug arrived on the 23d, and the first barge-load of gabions was towed out on the 27th, (Tuesday,) in the afternoon. A considerable time had elapsed since the last gabion had been placed, and the action of the water had caused a bank of shells to form over the area where the placing of the gabions was resumed.

It is very slow work to place gabions in such localities, since the piles cannot be driven deep enough to hold, and the sand-pump does not move the shells readily.

The number of gabions sunk in the three days the work was continued does not, therefore, give a correct idea of the capabilities of the means employed in sinking gabions under the ordinary circumstances of tide and the conditions of the bottom.

The construction of the gabion was continued as follows: 74 gabions wove, 104 gabions completed, 279 blocks of concrete made, 270 mats made, 314 fascines made, 626 bundles of canes trimmed, 395 barrels of cement used, 355 barrels of sand used, 476 barrels of brick used, 85 barrels of gravel used, 3,080 stakes used, and 9 small gabions completed. A comparative examination of the inner bar was made on July 29, and a sketch of this is sent herewith. Some remarkable changes are indicated. The cutting out of the channel across the necks, uniting the middle ground with the knoll, has already begun, and deep water is now found in the vicinity of the new work.

The swinging of the lines of jetty farther to the eastward appears to be the proper course to pursue under the present circumstances.

The inclination of the tide to form a channel in a northeasterly direction being apparently opposed by the drifting in of the sand by the incoming tide, and that the placing of the jetty so as to arrest this drift is the only requisite, the ebbing tide having sufficient force to excavate a channel without any confinement by jetties.

* * * * * * *

On September 4 a report was made for August, from which the following is extracted:

* * * * * * *

During the month the work of sinking gabions has been continued with flattering success, though prosecuted in the midst of aggravating difficulties.

The tubes of the boilers on the tug and dredge have been leaking to such a degree as to frequently cause the entire suspension of the work, until the necessary repairs could be made; from the absence of the necessary tools in Galveston with which to make these repairs, considerable delay in the resumption of work has resulted each time, and although the results present a favorable showing for the amount of time actually employed, still it can hardly be accepted as an average exhibit of the capabilities of the system of working under ordinary circumstances.

It is believed that most of the difficulties arising from the imperfections in the construction of the boilers used on the dredge have been surmounted and that in the future better results may be anticipated.

The second barge was completed the last of the month; but one barge was therefore available for transporting gabions, and in consequence considerable time was lost in loading the gabions upon this barge; that will not occur hereafter, in consequence of having one barge ready to replace the other as soon as empty.

On the 10th the experiment of continuing the work night and day was begun, and the advantages of this plan clearly demonstrated.

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The subjoined table will exhibit the number of gabions placed each day, and explain the causes of delay:

Date.	Number of gabions sunk.		Remarks.
	6 feet.	12 feet.	
August 1	.....	.....	Rough water, preventing operations on the jetty.
2	.....	.....	
3	6	.....	Operations suspended in early part of the day by leaking of tubes in boiler of sand-dredge.
4	4	.....	Resumed work in the evening.
5	.....	.....	Getting cargo of coal, and loading barge with gabions.
6	10	.....	
7	18	.....	Delayed in repairing boiler on tug. (Last of the 6′ gabions.)
8	.....	.....	Repairing boiler on tug; unable to tow barge in position.
9	.....	5	Resumed work in the evening.
10	.....	7	Feed-pump of boiler on dredge failed; obliged to suspend work for the night.
11	.....	6	Feed-pump working badly during twenty-four hours.
12	.....	4	Tubes in boiler of sand-dredge leaking so as to extinguish fire completely at noon.
13	.....	5	Resumed work at 6 p. m.; at 11 p. m. sea very rough; work discontinued.
14	.....	.....	Getting cargo of cement and loading gabions.
16	.....	5	With much difficulty; sea so rough as to break entirely over the barge.
17	.....	13	
18	.....	10	Reloading barge; stiff norther blowing.
19	.....	7	Heavy sea; resumed work at 9 p. m.; driven off again at 3 a. m.
20	.....	5	Storm continues; barge and sand-dredge blown in contact, and suction-hose collapsed.
21	.....	.....	Repairing suction-hose.
23	.....	11	Encountered shell-reef; sand-pump worked slow.
24	.....	8	Tubes again leaking in boiler of sand-barge; hauled off for repairs.
25	.....	1	Resumed work at 6 p. m.; strong tide; boats dragging; discontinued work until morning.
26	.....	7	Encountered shell-reef; dredge worked slowly.
27	.....	5	Contending with strong tide day and night.
28	.....	.....	Repairing boiler of sand-dredge.
30	.....	11	
31	.....	9	Greater part of the night consumed in repairing foot-valve to sand-pump.
	35	119	Total number of gabions sunk.

The first line of jetty was extended to a point 1,600 feet from the end of the pile breakwater on a line slightly to the westward of the light-ship, when the water became so shoal as to endanger the gabions when landed overboard from the scow.

A second line, about 75 feet in rear of this line, was commenced, and extended about 500 feet.

At a distance of about 500 feet from the pile jetty, a stratum of soft mud, overlain by a thin stratum of shells, was met. The shells were not readily moved by the sand-pump, and the filling of the gabions progressed very slowly. The mud was not attacked by the pump, and frequent stoppages resulted from the shells being all moved from the surface of the mud by the pump.

The gabions resting on this mud sank over half their height when filled, and it is believed that it will be necessary to place a row on top of these to accomplish much good. The guide piles were easily driven 10 to 12 feet into this mud by an ordinary wooden beetle.

A strong tide sweeps over this spot, and some difficulty in getting the gabions in exact position has been encountered in consequence, but the sinking party are improving with time, and the work is continued without much regard to the tides or weather; in fact, I am not sure but they hold on too long sometimes, for the dredge, scows, and boats were driven over the jetty on two occasions by storms, knocking the tops off of two or three gabions, and injuring the vessels slightly.

Mr. Ripley's absence has not permitted us to make any survey of the inner bar this month. The gradual increase of the east end of Galveston Island has continued, however, and some changes in the appearance of the shoals to the northeast have occurred.

The pilots report that the channel across the inner bar has moved to the westward, and is quite narrow.

It is quite likely that this channel will close entirely, and a new one form in the vicinity of the jetty; for this reason it would appear to be advisable to continue work on the present ground until this change takes place.

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The work of construction has been continued as follows:
68 gabions completed.
57 gabions wove.
77 gabions first coated.
70 gabions concreted.
451 concrete blocks made.
84 mats made.
126 facines made.
302½ barrels cement used.
262 barrels San Jacinto sand used.
576 barrels screened gravel.
1,066 bundles of cane, trimmed.
2,680 poles used.
67 bottoms staked.
73 tops put on.
54 tops covered.

The survey launch is nearly completed and it is believed that it will be ready for use by the 18th of September.

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On October 4 the following report was rendered for September:

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The process of sinking gabions in the second row, forming the jetty extending from the end of the old breakwater seaward in the direction of the Galveston light-ship, was continued with fair progress until the total failure of the tubes in the boiler of the sand-dredge caused a suspension of operations. The exact number of gabions placed during the month is unfortunately, from the loss of the record-books, a matter of conjecture, but was in the neighborhood of 100, 72 of which were placed in one week.

The construction of gabions had progressed moderately, but 25 large-sized gabions had been first coated and as many woven. A number of tops and bottoms for large gabions were completed and every arrangement perfected for pushing the work with dispatch. Then in one night everything except the completed gabions were swept away by an extraordinary storm. This storm really commenced on the 14th of September, and continued with increasing force till toward the evening of the 15th, when a decided temporary abatement occurred, after which it continued to increase in violence, the wind blowing from the northeast, at the rate of 40 miles an hour. The tide rose rapidly, and toward midnight the buildings at Fort Point were all swept away, and the Government employés forced to take refuge upon the piles used to suspend the boats from.

The steam-tug Mulyneux was disabled, and not therefore available at this critical time for attempting the rescue of the employés at the point, and it is, indeed, very doubtful whether she could have weathered the storm at night when the situation became alarming. The Houston D. N. Co.'s tug was obtained, however, and, manned with a volunteer crew, proceeded to the point, and rescued the employés from the piles and flats early on the morning of the 16th. But two men are missing, and in view of the fact that assistance reached the men at the earliest possible moment, it is indeed fortunate that the loss was not greater.

The water continued to rise in the bay, and on the 17th stood 6.48 feet above mean low-water inside the Merchant's Press on the strand.

The wind gradually worked around by the S. SE., S. SW. to N.W., in which quarter it subsided. The strongest wind during the gale came from the N.W., and moved at the rate of 60 miles an hour. The effect of this wind was to drive the vast body of water accumulated in Galveston Bay by the N.E., E., and S.E. winds out to sea, and it is possible that the very considerable changes produced in the condition of the east end of Galveston Island are due to the strong currents which swept across this portion of the island under the influence of this wind.

On the 19th I visited the breakwater and found that nearly three-fourths of the work constructed by the city of Galveston was entirely swept away, and the remainder so badly damaged as to require very extensive repairs.

Several channels are cut through the island, and a large portion of the land formerly above high-water is now completely covered with water at low-tide.

The destruction of all the ranges prevented our determining more concerning the gabion-jetty than that part of it was still standing, and that but 3 feet of water existed on the seaward side, where 6 feet had existed before the storm. An examination by the diver will be made as soon as the weather is propitious.

A deep channel exists across the inner bar, and the knoll has shifted to the south and closed the old swash-channel.

In the yard where the gabions were constructed there is but little land remaining above water. The gabions lie in confused masses, those recently constructed having scarcely any plaster adhering to them, while those thoroughly seasoned were but little

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injured, and only where they appear to have collided with each other while empty. They are nearly all canted considerably toward the east, and sunk more or less in the sand. Those on which the plastering remains are, in general, nearly full of sand. The small-sized gabions appear to have withstood the storm better than the larger sized, though they had been finished a much longer time and were thoroughly hardened.

All these gabions were exposed to the direct impact of the waves while entirely empty; that any remain or retain their cement-coating is, under the circumstances, indeed marvelous, particularly when we contemplate the wrecked condition of the pile breakwater in their immediate vicinity. Many floated off when the water rose sufficiently, and about 30 were lost off the scows. There still remain in the yard 25 small gabions and 35 large gabions in one place, and 20 large gabions in another, all in about the location they occupied previous to the storm.

The gabions used as cisterns floated as soon as the water became deep enough, and were scuttled by the men to prevent their injuring the buildings; they remain about as left.

The number of gabions on hand at the time of the storm is presumed to have been 150 large sized and 80 small-sized. All our records were lost with the buildings, and it is possible that our estimate is too great; in any event, not as many gabions are missing from the yard as might be expected.

All the material is swept away, and a complete loss; excepting the cement, there was on hand about sufficient material to complete 300 gabions, or a three months' supply. This was so disposed as to have safely withstood ordinary storms, such as had previously come under my observation.

Our vessels were considerably scattered by the gale and all more or less injured. One of the scows was picked up 50 miles out at sea, the other caught in the end of the breakwater, and is but slightly injured. The sand-dredge broke from her moorings, and was landed high and dry about 2 miles from Virginia Point, near Highland Station on the Galveston, Houston and Henderson Railroad. The divers' flat is still missing; the tug Molyneux had her bulwarks on one side carried away, and her house injured by colliding with other vessels, after slipping her cables to escape from a wreck which had drifted against her. All the small boats were more or less injured.

The sand-dredge lies in such a position as to render the abandonment of the hull advisable. The machinery can be readily placed in a car on the railroad and brought to Galveston, where it can be stored till a new boat can be built to receive it.

A resurvey of the inner bar and the east end of Galveston Island has nearly been made, and the results will be forwarded at the earliest possible moment. No recommendation for the continuance of operations at the east end of Galveston Island can be offered at present, owing to the very extensive alterations which have occurred in this locality, but it is believed that the work of constructing the jetty on the north side of Bolivar Channel might be commenced at once with advantage, the new depot to be established on Bolivar Peninsula.

From the manner in which the gabions on shore and those placed in the jetty withstood the late storm, there can be but little doubt of the advisability of continuing the construction of this species of jetty, particularly in those localities where the gabions will be exempt from the scouring effects of currents, which flow parallel with the jetty which they form.

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The losses caused by the storm reported, which were estimated as amounting to about $50,000, put a sudden stop to jetty construction for the season favorable for such work. The first step afterward was to collect and secure such property as was left. The next was to survey and consider the changes effected by the storm on the end of Galveston Island and in the channels and shoals about the harbor and its entrance, and the manner in which the experimental jetty structure had behaved.

The next was the replacement of plant, the preparation of a yard, and construction of buildings on Bolivar Peninsula; the collection of material, the modification of details of construction, and the manufacture of gabions, &c., in time to take advantage of the favorable season of summer to continue jetty construction. These steps were taken in succession, and the close of the year found the work on the same footing as at the time of the storm, but with so small a balance of appropriation as to necessitate suspension a few days afterward. Details are shown by continuation of extracts.

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Under date of October 13, I reported as follows to the Chief of Engineers:

* * * * * * *

I have delayed my September report of operations for the improvement of the entrance to Galveston Harbor, thinking it probable that the survey directed immediately after the great storm would have by this time been advanced far enough to enable me to present a detailed description of the changes effected by the storm in the channels and shoals of the harbor and entrance.

The preliminary work of the survey having been greater than I expected, owing to the loss of instruments and of records and land-marks of previous surveys, it will not be possible, therefore, to present a chart for comparison with previous charts before the close of this month. In the mean time, I submit the inclosed report of Lieutenant Quinn, which gives information on which I think we shall be warranted in at once resuming the work of improvement.

The cheapness of the gabion-jetty has been demonstrated in previous reports. The stability of the structure I think may now be considered as beyond question. The applicability of jetties as planned for this harbor entrance I believe has not been doubted. The demand for improvement is now, if anything, greater than it has been heretofore. These four assumptions justify resumption of the work.

When the present survey is completed a change of location of the jetty from the head of Galveston Island (Fort Point) may be suggested, but in the location of the Bolivar Point jetty there can be no change.

I stated in my annual report the importance of running this jetty out to catch the drift from the east, which has no doubt in a great measure built up the inner bar and Pelican Island and spit.

I am now convinced that this jetty should be built out in advance of that at Fort Point at least far enough to cover the inner bar, and therefore approve the recommendation of Lieutenant Quinn that work be commenced on it.

Should this meet the approval of the Chief of Engineers, I have the honor to request authority to procure by lease the use of suitable grounds on Bolivar Peninsula, to build on them quarters, store-houses, and sheds of the same character and dimensions as those recently destroyed at Fort Point, and to at once provide the work with boats, tools, instruments, &c., to replace such as have been lost, and to place the work on the footing it held before the storm. It is thought that this may be accomplished by the close of November next.

If the work be recommenced, as above proposed, I have the honor to request that about the 1st of December a board of engineers be convened in Galveston to make personal examination of the work, and to report on what has been done—conclusions drawn from work done, and what results may be expected from continuation of the work.

This request is not made on account of any doubt on my part as to the propriety of continuing the work, but because I think the report of a board of engineers would add strength to the work before Congress.

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The officer in superintendence reported as follows, on November 3, for October:

* * * * * * *

The resurvey of the inner bar and the east end of Galveston Island has been completed, with some slight exceptions, and the plotting has progressed with as much expediency as possible, the absence of the requisite instruments materially interfering with this branch of the work. A protractor for plotting sextant readings was improvised, which, though quite accurate, is not particularly convenient; nevertheless, encouraging progress is being made with it, and a gratifying solution of what at first appeared to be a perplexing problem is practically solved. The labor of recovering the Government property dispersed by the late cyclone has been diligently prosecuted, though no very considerable success has attended our efforts so far. Several gabion tops and bottoms have been recovered and stored on the barges. The hull of the sand-dredge was abandoned after removing the machinery. The machinery was brought to Galveston and stored on the barge with the gabion-tops.

The temporary boarding-house for the employés, erected on one of the barges, was so far completed as to be occupied the last of the month.

The steam-launch is nearly completed and would probably have been completed had the contractor not been sick.

The gabion-jetty has been thoroughly examined by the diver and found to be in thorough order. No serious settling has occurred. In fact, the gabions have not settled near as much as was to be expected, and the admirable manner in which the work

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withstood the very severe test through which it lately passed, is indeed a most agreeable surprise.

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And on December 2 as follows, for November:

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During the first part of the month an endeavor to construct a few sample gabions for the inspection of the board of engineers, was made at Fort Point, but a high-tide carried off what material had been accumulated, and forced a discontinuance.

In pursuance with telegraphic instructions all the employés except those necessary to guard the property and continue the survey in progress, were discharged. The steam-launch was completed and is being used by the survey party.

The new sand-dredge flat was nearly completed and will be launched by the 5th of December.

A number of forms used in the construction of gabions and a lot of molds for concrete blocks were made. A few bunches of canes and a few stakes and piles were received the last of the month, (26th.)

The plotting of the field-notes of the survey of that portion of the inner bar affected by the recent storm, was completed, and the shore-lines of Galveston Island and Bolivar Peninsula included within the limits of the proposed new chart were run, and a portion of the field-work plotted.

* * * * * * *

This further loss reported was light, consisting only of a small amount of material collected for construction of a few gabions, in view of an expected visit from the board of engineers, requested in my letter of October 13.

On October 27 the officer in superintendence was instructed as follows:

* * * * * * *

In connection with the meeting of the board it is also desirable that you have prepared in the most careful and complete manner, a succinct history of the work as heretofore conducted, showing its progress in detail, its result, its cost at various periods, and everything relating to its management.

* * * * * * *

The following report made in compliance with the above, gives facts, views, &c., of interest:

* * * * * * *

The arrival of the tug for towing out the barges loaded with gabions, coupled with the prevalence of favorable weather for a season, enabled us to arrive at valuable data concerning the work that otherwise was inaccessible.

The experience so far gained in placing the gabions, indicates that the immediate proximity of the factory for gabions, &c., to the locality to be occupied by the jetties, is not of such importance as at first supposed, and that, in fact, two or more works could, if not too far apart, be supplied simultaneously with gabions from a single yard with marked economy. In the case of a single work this comparative independence of propinquity between the factory and the jetties, largely extends the ranges for the most judicious site for the accumulation of materials and fabrication of gabions.

Although it is possible to proceed with the construction of the jetties in moderately rough weather, it is not considered advisable for economical reasons to do so, but rather to confine the operations during the inclement season to the fabrication of the gabions and accessories, and proceed with the other work during the summer. In fact, it is decidedly injudicious to attempt the removal of a gabion from the yard until it has had about two months to mature in, and, as they improve with age, it is desirable to have a large lot on hand in the yard, upon which to draw when the active operations of sinking are commenced.

As the materials of which the gabions are made occupy, in the crude state, considerable space, and some space is also necessary for the requisite shops, store-houses, and mens' quarters, the yard should be situated upon a plateau of adequate dimensions, bordering upon water of suitable depth to accommodate the different vessels engaged in the work, and, if possible, sufficiently elevated to be beyond overflow by extraordinary high-water. If such a spot can be procured within convenient distance of the jetties, and easy of access, nothing better can be desired.

If no interruption, through failure of boiler or breakage of machinery of sand-dredge, occurs, between 300 and 400 gabions may be placed in the jetty monthly during April, May, June, July, and August of each year, and with a second sand-dredge, costing about $10,000, double this number could be sunk each month, or say, 3,000 gabions during the quiet season.

With our present facilities 1,500 gabions are as many as we can expect to sink in one

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season. The gabion-yard should, therefore, have sufficient space for storage of 1,000 gabions, besides the space necessary for quarters, material, &c., or an area of not less than 500 feet square.

The position on Bolivar Point, indicated on the chart, possesses the necessary qualities for a convenient and commodious gabion yard, a channel having formed along the front of this locality, connecting with the deep water of Bolivar Channel, and having sufficient depth to admit the tug at mean low-tide.

The land will be leased for a sum just sufficient to defray the cost of drawing up the necessary papers, or not exceeding $100 a year. To reach the deep water, a wharf 300 feet long will be required. The establishment will cost as follows:

Wharf with tramway	$1,000
Quarters for men	1,500
Store-houses and carpenter-shop	800
Sand and gravel bins	400
Contingencies	300
Total cost	4,000

The only change in the method of placing the gabions, &c., in jetty, which we have to recommend at present, is to have the mats placed in advance of the line of gabions, in such a way that the gabions will rest upon the brush extremities of the mats, the mats to be slightly increased in thickness, and the concrete weights also to be slightly increased in size.

The condition of the gabions left in the yard at Fort Point, after the storm of September last, indicates the necessity of their having ample time to become thoroughly hardened before being placed in the jetty.

The dimensions of the holes left in the covers of the gabions do not appear to be of such importance as at first supposed, and as the principal objection to coating the inside of the gabions with cement was mainly due to the necessity of having access to the interior, this change may be made with possible benefit, since one of the apertures in the cover may be of sufficient size to admit a man, without seriously weakening the covers, or permitting the sand filling to escape in any material quantity. The interior coating of cement will increase the strength of the gabions, and in case the outer coating is injured, through accident, while sinking, will prevent the sand filling from escaping; it will add $6.75 to the cost of each gabion, and is certainly worth this as a precautionary measure alone, although possibly not absolutely essential. Two diagonal iron bolts are believed to be necessary to properly strengthen the tops; these will cost $1.92 per gabion.

The tops have heretofore been protected from the ship-worms by a coating of cement, but it is liable to become detached through handling of the gabions or shrinkage of the lumber, and is not entirely efficacious. Crude carbolic acid and asphalt are now obtainable, and the tops may be economically treated in such a manner as to effectually preserve them; this treatment will add but 25 cents to the present cost of a gabion.

Cost of one gabion, June last	$62 53
Add for cement coating inside	6 75
Add for 2 diagonal bolts	1 92
Add for asphalting cover	25
Add for increase in size of mats and weights	2 00
Total	73 45
Total cost per running foot of jetty	6 12

Referring to the chart of the recent survey of Galveston Harbor, several remarkable changes will be at once observed.

The eastern point of the island has altered considerably, channels being cut where, previous to the storm, houses were standing.

Deep water exists along the face of the gabion jetty, and the "swash-channel" is effectually closed.

But little of Pelican Spit remains above water.

The "Knoll" is changed in a remarkable manner, and shifted far to the eastward.

The gabion jetty was completed, as indicated on the chart, on the 13th of September, and stood, without further injury than a settling of from 3 to 6 feet, the fiercest storm which has visited Galveston for a number of years.

The jetty was composed of two lines of gabions connected by cross-lines, as represented; the line next the channel settled considerably; the back row not near so much. The gabions were all in position and uninjured when examined by the divers.

The strongest wind, and the wind which caused the remarkable scouring out of the channel, came from the northwest, or nearly perpendicular to the line of gabion jetty. (See accompanying chart, showing the force and direction of winds and amount of rain-fall at Galveston, September 14 to 18.)

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The pile breakwater, constructed by the city of Galveston, and subsequently strengthened by the United States, was so badly injured by this storm as to require almost entire renewal.

Pelican Spit was probably washed away by the storm which came from the NE. and E.

Passing to the outer bar it will be observed that a new channel cut across the bar on the prolongation of the Bolivar Channel, while the approach to the old ship-channel has narrowed, is very tortuous, and in fact appears to have been formed since the cyclone.

By referring to the wind-chart it will be observed that the storm originated in the NE. and gradually veered, by E.SE., &c., to NW.

The tide rose rapidly while the wind was veering from NE. to S., and a strong current swept along the coast towards the SW. This current was arrested and caused to flow in the opposite direction by the veering of the wind to SW., and was running rapidly to the NE. when the winds from the NW. caused the expulsion of the water from Galveston Bay. The current flowing out of Galveston Bay encountered this current flowing along the coast to the NE., and as an inevitable result a channel was formed, as indicated on the chart.

The storm which occurred on the 25th of September was attended by precisely the reverse of the conditions attending the cyclone, and materially altered the condition of the phenomena resulting from it, while each succeeding storm has but aided in restoring the inner bar to its normal condition.

It is of vital importance to the commerce which seeks the harbor of Galveston that at least sufficient depth of water be maintained on the outer bar to permit vessels 18 feet draught to enter the deep water of Bolivar Channel. As it is at present, vessels drawing over 12 feet are obliged to anchor considerable distances from the outer bar, and the lighterage of cargo in and out is an expensive and hazardous operation; but once the vessels are in Bolivar Channel, if there is not sufficient depth of water to permit the vessels to proceed to the wharves of Galveston, lighterage would be not only vastly less expensive, but possible under nearly all conditions of weather. If this much to be desired result is possible of attainment by the construction of a jetty, as suggested, the saving to commerce in lighterage, demurrage, and damages in one year would fully cover the expenditures.

A table giving the level of high-water marks of the storms of 1867 and 1875, referred to mean low-water, is appended. As the mean fluctuation of the tide is 1.1 feet, an elevation of the water 8 feet above ordinary high-water is suggestive.

As the cyclone destroyed all our charts, notes, and instruments, the resurvey has been prosecuted under great difficulties. We were obliged to commence anew the collection of data with such instruments as could be borrowed or improvised. New instruments to replace those lost are now being received, and many of the difficulties are in consequence disappearing; yet, since most of the data embraced in the chart were collected without their aid, I take pleasure in referring to my assistants in earnest commendation of the very able manner in which the work has been prosecuted by them.

On the 20th of December a board of engineers was convened in New work City to consider matters connected with this work of improvement.*

The officer in superintendence reported operations for December as follows:

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The new scow for the reception of the machinery of the sand-dredge was completed and launched, and the machinery placed on board. The almost incessant rain during the latter portion of the month materially interfered with the adjusting of the machinery and constructing the necessary house to cover it in, but by working during every available moment the dredge was put in such order as to be capable of pumping sand when desired. One of the sections of 6-inch flexible hose was lost during the storm; and as it was absolutely necessary to replace it, it was ordered from New York, as was also a 4½ feet length of galvanized iron pipe and two 10 feet length of 4-inch flexible hose. (Permission for the purchase of this is desired.)

The wretched condition of the weather has materially interfered with the prosecution of the survey; fortunately, however, the possession of the steam-launch Fascine enabled the party to complete the soundings on the outer bar in time to permit their plotting upon the chart presented for the consideration of the Board of Engineers convened in New York. The whole of the soundings were taken on the outer bar during part of two days, the only opportunity presented for a long time. The lines run aggregate 70 miles, and the time occupied was 14 hours and 12 minutes; this is at the rate of about 1 square mile of soundings per hour, or about seven times as much per hour as was ever accomplished at this place with sail or row boats.

*For report of board, see Appendix J 3.

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The survey of Pelican Island and the shore-lines of the bay, embraced in the limits of the proposed survey, were run and plotted, and seven lines of the main triangulation worked up.

The sample gabions for the inspection of the Board of Engineers were completed, with the exception of the concrete ballast, the requisite gravel for which it was impossible to obtain on account of the bad weather. The rough weather has prevented any further examination of the gabion jetty at Fort Point, but its position is distinctly marked by the breakers that form along its crest.

The gabions which remained in the yard after the storm have passed through all the succeeding storms without any change in condition and position.

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And for January, as follows:

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The derrick and engine and pump-connections of the sand-dredge were completed, and the concrete ballast placed in the 10 gabions constructed for the inspection of the board of engineers. Eighteen mats were completed. A plat for the divers was nearly finished. The steam-launch was hauled out, and the wheel changed for one of ranker pitch; the hull was repainted, and a light deck placed over the machinery to protect it from the rain; an awning was provided for the rest of the cabin space.

The survey has progressed as rapidly as the weather would permit. The shore-line in the vicinity of Virginia Point was surveyed and plotted, and the primary triangulation of the general survey completed.

The cross-sectioning of the gabion jetty was nearly completed, and will be finished early in the present month.

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On the 21st of January the following letter of instructions was transmitted to the officer in superintendence:

UNITED STATES ENGINEER OFFICE,
New Orleans, January 21, 1876.

SIR: The Chief of Engineers having directed that the work for improving the entrance to Galveston be resumed and conducted in strict accordance with the recommendations of the board of engineers recently convened in New York City to consider and report upon the subject, authority is given you to recommence the work, observing the following instructions:

1st. Select grounds for buildings and yard on the bay side of Bolivar Peninsula, and secure a suitable lease for it, which will be subject to the approval of the Chief of Engineers.

The lease should be from month to month, the United States having the privilege of extending it month after month on the terms agreed upon for the first month so long as desirable for the use of the work.

Also to have the privilege of removing all buildings after annulment of lease.

2d. Having secured lease, erect the necessary buildings for a force of 80 men; these buildings to consist of the following:

1. Officers' quarters, to contain rooms for two assistant engineers, one overseer, and one clerk, one office, one draughting-room, one dining-room, one kitchen, with cook's sleeping-room off it; the officers' rooms in second story.

2. Men's quarters, with rooms for foremen, dining-room, kitchen, cook's room, and store-room for provisions.

3. Carpenter's shop.

4. Store-house.

5. Blacksmith-shop.

6. Such sheds as may be necessary for morter-beds, sand and gravel storage. These buildings to be located at such distances apart as to insure against fire; to be built in the cheapest style consistent with comfort and stability, and by hired labor, the material being purchased in the open market.

3d. Construct such wharves, ways, cisterns, and water-closets as may be required for the work and for comfort of employés. Have the ground you lease accurately surveyed, its boundary well marked and plotted; then on the plot locate these several buildings in plan, and send the plot to this office, together with detailed plans and estimates of the buildings.

4th. Purchase such kitchen and table furniture, and such tools, as may be required.

5th. Contract for material enough to make about 500 gabions, with their fascines, mats, and blocks.

6th. Employ all carpenters, plasterers, and laborers by the hour. Civil assistant engineers, overseers, foremen, blacksmith, cooks, waiters, and persons employed on vessels, by the month. Wages should be reduced to the same as those given now by private parties who board their employés. Civil assistants, overseer, clerk, and offi-

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cers of vessels, while retaining their present pay, will, after completion of buildings, be required to board on the work.

7th. Provisions will be procured under existing agreement.

8th. Instructions will be given at a later date for prosecution of work on jetty.

9th. The following reports will be made to this office:

1. By telegraph after 3 p. m., every Saturday, stating balance of funds on hand.

2. A short report to be transmitted every Monday, giving general account of progress during the past week.

3. A report at the close of each month, in the form inclosed, marked "A."

4. All vouchers paid during each week will be transmitted at the close of the week during which paid.

5. With each monthly report will be sent a chart of survey covering the inner bar, made as late in the month as practicable.

6. After buildings and yard are ready for occupancy, photographic views from not to exceed 6 points will be taken, and 4 sets printed, 3 sets to be sent to this office.

7. While buildings are in progress, you will carefully consider the recommendations of the recent board of engineers, and report a project for carrying them out.

It is desirable to have a large number of gabions ready for putting in position about the middle of May, at the latest, in order that further results on the inner bar may be had before the 30th of June.

Copies of report of board, and instructions from Chief of Engineers, are inclosed for your information.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers, U. S. A.

Lieut. JAMES B. QUINN,
Corps of Engineers, U. S. A.

The report for February was as follows:

* * * * * * *

The construction of the wharf and men's quarters was commenced immediately upon the arrival of the lumber. The piles for the wharf were nearly all put down, and the men's quarters were shingled and nearly completed. Arrangements for the early delivery of the materials for the construction of the gabions were made. An examination of the gabion-jetty was made during the month, and the results were carefully plotted, and will be forwarded as soon as a copy can be made. The examination was as thorough as was possible under the circumstances. The weather was very unfavorable, being quite foggy, and at no time particularly quiet. Piles were sunk along the presumed line of the jetty, and a line stretched at right angles to the line of piles or as near to a right angle as circumstances would admit. This line was held taut by means of anchors and the steam-launch, and the soundings were located from shore-stations.

The examinations of the gabions met in the course of the examination were made with the pole, any other examination than with a diver being impossible. The gabions are nearly all covered with sand, the back or seaward lines being almost entirely so. The apparent breaks in the lines of gabions encountered during the examination results from the swaying of the line from one side to the other. The pole not meeting with a gabion when put down, no search was made, but the depth of water was alone recorded. Time did not admit of a thorough search or location of all the gabions, and it was, therefore, deemed sufficient to examine those only which were met while sounding the line, the diver having previously reported that the line of gabions was intact. Since the lines of soundings did not coincide with the line of the gabions, the plotting of those gabions encountered is calculated to leave the impression that the line is defective, and that many gabions are missing. In order that no doubts may exist in regard to this, I will myself, during the present month, descend in the diving-armor and examine the locality in person, and endeavor to obtain a correct location of the lines of gabions not covered by sand. Aside from the condition of the gabions themselves, the influence which they exert in maintaining and directing the channel across the inner bar is not only "apparent," but it is *emphatic* and *decided*.

No important storms have occurred since the 25th of September last, yet the depth of water has steadily increased upon the inner bar, until a depth sufficient to admit vessels drawing 13 feet of water now exists. The water is slightly deeper on the inner bar than on the outer bar. The examinations of the shore-lines, embraced in the principal survey of Galveston Harbor, are about completed, and the services of the additional assistant engineers were dispensed with at the termination of the month.

A re-examination of the inner bar was made the latter part of the month, (February,) and the soundings, so far plotted, indicate not less than 14 feet depth of water in the channel across it. The tracing of this survey will be forwarded on the 7th or 8th.

* * * * * * *

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The report for March was as follows:

* * * * * * *

During the month the wharf at Bolivar Point was nearly completed, and the tramway, leading from it to the several portions of the yard, was nearly finished. The house placed on No. 2 Barge was moved ashore, placed on a foundation, and fitted up for a cement shed. A carpenter-shop was built, and the quarters for the men finished and occupied. Some material for gabions was received and stored, and implements for constructing gabions were obtained. The survey of the harbor was continued, and a re-examination of the inner bar, made during the month, disclosed the fact that the process of scouring out had still continued.

* * * * * * *

On April 6th, the following letter of instructions, to the officer in superintendence, was transmitted:

UNITED STATES ENGINEER OFFICE,
New Orleans, La., April 6, 1876.

SIR: As your preparations for resuming the work for the improvement of Galveston Harbor approach completion, changes in details of construction of gabions and mats, to meet the views of the board of engineers recently convened to consider the propriety, &c., of continuing the work; also, improved methods of moving the gabions, &c., to position, and of placing them in position, have to be considered. Your views as to these matters have been called for, but as yet have not been received at this office. In default at this late day of such views and plans as it was expected you would present, the following are sent for your guidance.

In regard to details of construction, the board made the following points:

1. The gabions should be better stiffened from the inside.
2. The cement coating should be thicker.
3. A cement coating should be added on the inside, as you recommended.
4. No projecting ends of stakes or edges of covers should be permitted.
5. The tops and bottoms should be carbolized.
6. The cross-pieces of the covers should be beveled, so as to better hold the cement covering to be spread over the top.

In making the construction to meet the views of the board as fully as possible, the following is directed:

1. To stiffen: For each gabion there will be put two frames of 1½ inch lumber, 6 inches wide, along the sides of the 12-foot gabions, and of suitable width at the ends to give plenty of room for three tree-nails in each. Each frame will be of 8 pieces, namely, 2 sides, 2 end, and 4 to connect. The lumber to be undressed and of cheap quality.

The tree-nails connecting the pieces of the frame are to be wedged at both ends. One of these frames is to be placed 2 feet above the bottom, the other 4 feet above the bottom.

At the middle point of each, and at 3 feet on each side, cross-pieces of 1-inch stuff 6 inches wide will be nailed on.

These frames will be notched for each stake and care taken that each stake fits its notch without having to be bent.

Each stake will be nailed to each frame as well as to the top and bottom.

2. The cement-coating will be made at least 4 inches thick from inside to outside of gabion. Any greater thickness, up to 6 inches, it is left at your discretion to direct.

4, 5, 6, and 7 need no explanation.

Rough drawings are sent you herewith to illustrate the foregoing.

MATS.

The Board insisted upon mats extending underneath the gabions, and for a distance each side proportioned to depth of water in which placed.

A depth of 12 feet is that for which the dimensions given on the inclosed sketch are directed.

The mats are to be made the same as the hurdles used in field-fortification, but with this addition, viz, the trimmings of the cane used for gabions are to be woven in so as to make a rough mat that will catch sand enough to cover up the stakes and watling and so protect them from worms.

Each gabion will have its own mat and be fastened to the latter by galvanized-iron wire, as shown in the sketch.

Fascines will also be attached to each gabion (four to each) as shown.

As a guide for putting the gabions in line, poles 1½ or 2 inches in diameter will be fastened to each end, as shown in the drawing; these to be long enough to project above water when the gabion is placed, and to be cut off by the diver after they have sufficiently served their purpose as range-poles.

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The fascines are to be fastened so that the diver may wedge them in between the gabions after the latter are in position.

The weights will be placed on the mats as heretofore.

It is desirable to know if the mats with gabions on them, properly ballasted, may not be towed into position on rafts, and thus do away with the use of the gabion-scows.

You will make this experiment as soon as possible, and fully report immediately afterward the particulars.

It is also desirable to know if wrought-iron tubes, 30 feet long and 4½ or 5 inches in diameter, may not be substituted for the guide-piles heretofore used. These may be rapidly put in place and easily taken up after they have served their purpose. I think they may be used for anchorage of dredge, &c. Four of these tubes have been ordered from New York; on their receipt you will make experiment with them and report fully.

Each gabion-top when made will have the holes left for introduction of sand-filling fitted with a suitable stopper to be put in by the diver after the gabion is in position and filled.

Before putting this stopper in, any space in the gabion not filled by the sand-dredge will be filled. After putting in the stopper it will be covered with cement.

The means for carrying out these instructions will readily suggest themselves.

The filling may be done with a hand-dredge.

The cement can be put down in a closed bucket having a trap for dumping.

The work of ballasting mats, the fascinage between gabions, the completion of filling, putting in stoppers, and covering the latter with cement, will of course belong to the diver's party.

There are other matters regarding facilities for handling gabions in the construction-yard, and when being put in place, which I leave to be decided upon after personal consultation with you.

The decision of the Board in regard to order of construction of the jetties, and in regard to location, is sufficiently plain.

The Fort Point jetty is to be completed to the full length and height necessary to secure an 18-foot channel across the inner bar, but in the mean time you will take advantage of good weather to put down the experimental section of the Bolivar jetty.

This experimental section the Board strongly insist upon, and it is important that it should be put down as soon as practicable.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers, U. S. A.

Lieut. JAMES B. QUINN,
Corps of Engineers, U. S. A.

The following was the result of operations during April:

* * * * * * *

Amount of work done during the month: Carpenters made 140 gabion-bottoms, 45 gabion-tops, 526 yokes, 115 frames, 25 gabion-trucks, 14 concrete-molds; built blacksmith's shop, 16 by 24 feet.

Blacksmith: 185 gabion-bolts made. Balance of month occupied in general work, as shown in tabular statement.

Laborers made 214 fascines; wove 67 gabions; molded 159 concrete blocks; carbolized 110 gabion-bottoms; carbolized 27 gabion-tops; concreted 46 gabions; staked 87 gabions; trimmed 2,624 bundles cane; received 101,940 feet lumber, 4,075 stakes, 2,980 bunches cane, (50 each bunch,) 10,529 cubic feet beach-sand, 1,678 cubic feet San Jacinto sand, 2,537 cubic feet gravel, 69 piles; constructed sand-bins, coal-bin, and sunk two wells for mortar-beds and quarters; and miscellaneous work, as shown in tabular statement.

* * * * * * *

During May, Lieut. C. E. L. B. Davis, Corps of Engineers, U. S. A., was placed in superintendence of the work, relieving Lieut. James B. Quinn, Corps of Engineers.

The result of operations for May has been reported as follows:

* * * * * * *

Amount of work done during the month: Carpenters made 124 gabion-bottoms, 238 gabion-tops, 317 gabion frames, 12 molds for molding concrete weights, 1 water-tank, (900 gallons capacity;) repaired launch; various repairs on tug; work of attaching machinery for propelling sand-dredge, (not yet completed;) and miscellaneous work.

Blacksmith made 292 gabion-bolts; worked most of the time on repairs and iron-work for sand-dredge.

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Laborers made 168 fascines; wove the canes in 128 gabions; cemented inside 139 gabions; cemented outside (first coat) 122 gabions; concreted (ballast) 144 gabions; cemented (second coat) outside, (completed,) 115 gabions; 146 gabion-bottoms were staked, (40 stakes in each bottom;) 596 concrete blocks were made.

* * * * * * *

At the close of the year the following report, covering the operations during June, was rendered by Lieutenant Davis:

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., June 30, 1876.

CAPTAIN: In obedience to your letter of instructions of June 19, 1876, I have the honor to submit the following report on the condition of the works of improvement of Galveston Harbor, Texas.

On my arrival in Galveston, May 16, 1876, I found that, owing to anticipated changes in the conduct of the work, everything had been kept in abeyance. Only the day before had orders been given to commence putting the sand-dredge in condition for active work.

Since my arrival the time has been devoted to pushing the work forward as rapidly as possible, on the "plant," as much valuable time for putting down gabions was being lost; at the same time the work at the construction-grounds was actively kept up, in order to get as large a supply of material and finished gabions on hand as possible. On the 3d of April, everything being in readiness to commence work, a force of men was employed for the construction of gabions; very soon after orders were received from the New Orleans office changing the construction of gabions somewhat, and requiring the use of some material of different dimensions from that on hand. This caused some delay, during which the men were employed in miscellaneous work, and the construction of gabions did not really actively commence until the 1st of May. On the 15th of May orders were given to have the machinery for propelling the sand-dredge made and put in, and to complete the attachment of a condenser to the boiler. A sufficient force was put on this work to keep up with the receipt of the machinery from the foundery as fast as it was completed, which work took until nearly the end of June. On June 7, lumber was ordered, and on the 9th work was commenced on the construction of temporary ways for hauling out the sand-dredge and barges Nos. 1 and 2 for repairs.

The bottom of the sand-dredge was cleaned of barnacles, and wherever worms had penetrated, new sheathing and tarred paper put on.

Both of the barges were entirely stripped of the old sheathing and tarred paper, and re-covered with new. This work extended through the month of June, and will require a few days in July to complete.

Necessary repairs to the tug-boat Molyneux (putting in new tubes and water-legs) will take till the first week in July for completion, after which time we shall be prepared for the work of sinking gabions in position.

The material on hand June 30 is as follows: 216 gabions completed, 54 gabions woven, 174 gabion-bottoms, 97 gabion-tops, 108 gabion-frames, 693 concrete blocks, 382 fascines, 8 mats, and a large amount of material for constructing gabions.

I transmit herewith the report of United States Assistant Engineer H. C. Ripley of the survey work during the year ending June 30, 1876. This report is so full as to leave little to be added, except that during the time I have been here the survey work has been pushed with commendable energy, and leaves nothing to be desired on the score of accuracy.

I also transmit the wind and rain record from November 1, 1875, to May 30, 1876.

At this port, during the year from July 1, 1875, to June 30, 1876, there was collected $63,854.80, and the duties on merchandise received in bond amounted to $43,154.83.

Entries and clearances from June 30, 1875, *to June* 30, 1876.

Vessels.	Entries.		Clearances.	
	No.	Tons.	No.	Tons.
American, coast	411	415,292	306	282,191
American, foreign	60	22,137	66	27,437
Foreign	129	80,232	121	66,589
Total	600	517,661	493	376,217

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Value of exports shipped to foreign countries during the year ending December 31, 1875, $16,116,458.

Value of same from January 1, 1876, to May 31, 1876, $7,890,815.

This improvement is in the collection-district of Galveston, Tex. The nearest light-house is on Bolivar Peninsula.

Very respectfully, your obedient servant,

CHARLES E. L. B. DAVIS,
First Lieutenant of Engineers.

Capt. C. W. HOWELL,
Corps of Engineers, U. S. A.

The following report of Assistant Engineer H. C. Ripley gives an account of surveys made:

GALVESTON, TEX., *July* 3, 1876.

DEAR SIR: I have the honor to make the following report relating to the surveys at Galveston, Tex., for the year ending June 30, 1876.

Work to be accomplished.—It was the design first to make monthly hydrographic surveys of the inner bar; second, to make a complete survey of the harbor, trigonometric, hydrographic, and topographic; third, to obtain such other information as should appear of value in connection with the improvement of the harbor.

In accordance with this design stations were erected for connecting at distant points by triangulation, and ranges were put up on Bolivar Peninsula for the purpose of sounding in the vicinity of the proposed jetty, extending from Bolivar Peninsula across the outer bar. Eleven ranges were put up and 5 large triangulation-stations built, when the storm of September came and destroyed them all, save one range. Attempts at sounding by means of ranges were therefore abandoned, and only the triangulation-stations were rebuilt.

After the storm, which swept away beacons and buoys and changed shore-lines and channels, it became desirable to make a survey, at once, of both inner and outer bars. Therefore, as soon as a sufficient number of stations to locate soundings could be built and located, the soundings were commenced, and a chart of the inner bar was completed in October and one of the outer bar in November.

Some remarkable changes in the channels and shoals were revealed by this survey as having taken place during the storm.

The gabion-jetty was to a great extent laid bare of the sand accumulation which had almost concealed it, and which was destined, in the short space of three months, to almost entirely envelop it again. This exposure afforded an opportunity to locate its position, which was approximately done in the following manner:

The tug-boat was anchored at different points along the jetty—as determined by sending down a diver—and her several positions located. The union of these points and the end of the breakwater by straight lines, and the addition of a line to indicate the back row of gabions, and these connected by cross-lines to indicate the wing-jetties, gives the position of the jetty as shown on the chart of that date.

Afterward, from January 24 to February 9, a more accurate location of the jetty was attempted in the following manner: A straight row of piles was first driven, the distance from pile to pile being about 100 feet, extending from the end of the breakwater in the direction, approximately, of the jetty; a line of sounding was then taken, extending 300 feet on either side of each pile, at right angles, or nearly so, to the row of piles.

Soundings were taken every 5 feet until the probability of meeting a gabion was passed, and thereafter every 10 feet, and locations were made once in 50 feet by means of two instruments at the extremities of a known base on shore.

Whenever a gabion was found, its position was accurately located and its inclination, if possible, ascertained.

The only defect in a complete location by this method was due to the accumulation of sand, which so entirely covered the jetty that only a few gabions, comparatively, could be found.

The union of these by straight lines, extended to correspond to the limits of the jetty as determined previously, and before described, and the addition of lines to show wing-jetties, gives its position as shown on charts subsequent to this date, (February 9.)

Three other surveys of the inner bar have been made; one February 25 and 26, one March 21 to 24, and one June 16 and 17.

After the storm of September a section across Bolivar Channel was taken, and compared with one taken from the chart of 1873, which shows that no material change had occurred in its area of discharge.

High-water marks at different points on the island and on Bolivar Point were determined by carefully-run level-lines. The result is tabulated below. It will be noticed that a difference of 3 feet in elevation existed on opposite sides of the island. This seems almost incredible, but there can be no doubt of its truth.

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Table showing elevations of high-water above mean low-tide during the storms of June, 1867, and September, 1875.

Location.	Elevation.	Year.	Authority and remarks.
	Feet.		
Southwest corner of 22d street and Avenue D	6.597	1867	H. Rosenberg.
Hendley Building, corner of 20th street and Strand	6.199	1867	Capt. Joe Hendley.
Inside of cotton-press, Strand, between 18th and 19th streets.	6.484	1875	Mark very distinct.
Northeast corner of 16th street and Avenue L	8.804	1875	Charles Weinberg.
Court-House, 20th street	8.090	1875	E. S. Fletcher, dep'y clerk.
Southwest corner of 32d street and Avenue M	7.549	1875	T. A. Washington, city eng'r.
Near southwest corner of 33d street and Avenue N ½	7.660	1875	Colonel Thrasher.
Southwest corner of 22d street and Avenue D	6.987	1875	A. Kory.
At Government buildings, Fort Point*	8.304	1875	R. M. Pease; less than extreme height.
Ship chandlery, south side of Strand, between 20th and 21st streets.	6.596	1875	A. Wakeler.
Saint Mary's College, Broadway	9.292	1875	Rev. Father Carrier.
Southwest corner of 10th street and Avenue L	9.496	1875	L. P. Whiting.
At light-house, Bolivar Point	8.622	1875	Light-keeper.

* The buildings were carried away when the tide had reached this height. It continued rising for some time afterward.

DETAILS OF SURVEY.

The survey of the entire harbor embraces an area of about 90 square miles, and, when finished, I think will be more complete, hydrographically, than any yet made of this harbor. It has been conducted on a plan similar to that of the Coast Survey for such work. The triangulation was executed with a sextant, and all stations and prominent objects have been plotted by co-ordinates. The accuracy of distances depend upon three distances determined by the survey of 1873. They are from flag-staff, Henley building, to Bolivar light, 22,673 $\frac{6}{10}$ feet; from flag-staff, Henley building, to north breakwaterbeacon, 23,364 feet; north breaker beacon to Bolivar light, 23,731 $\frac{7}{10}$ feet.

The true meridian here assumed was also determined by that survey.

The topography was executed with transit and stradia. It was commenced in September and finished in February.

The shore-line, as indicated on the chart, is that of mean low-tide.

The hydrography was accomplished in the following manner:

Soundings were taken on time from the steam-launch Fascine for a depth of 14 feet; a pole marked to feet and tenths was used, and for greater depths a line marked to fathoms and feet was substituted. Locations were made from the boat with two sextants, by measuring the angles from the three known objects. The frequency of the observations depended upon changes in depth, velocity, or direction. The apparent course of the boat was determined by compass; but its real course being so much affected by wind and tide, the accuracy of location of intermediate soundings depends upon the following principles:

If there exists a force, as of wind or current, in any direction not coincident with that of the boat, it will cause a change in direction. Supposing the velocity of the boat to be uniform, if this force be constant and uniform the actual course of the boat will be a straight line, and will differ from her apparent course in proportion to the relative amounts of the boat's velocity and the perturbing force. The location of intermediate soundings will be, therefore, in this case quite as accurate as though no perturbing force existed.

But if this force be uniformly changing, (increasing or diminishing,) the boat's actual course will be a curve whose radii of curvature are uniformly changing, (diminishing and increasing.) But if locations be frequently made, this curve can be determined, and hence the location of intermediate soundings will still be quite accurate. If, however, a sudden change occur either in the direction or force of the current, as is often the case in passing from flats to channel, or in encountering different currents where the Galveston Channel meets the Bolivar Channel on the inner bar, to insure accuracy it is necessary to make a location immediately before and after the change, and possibly to reject intermediate soundings.

If, however, instead of running by compass, we use a range to keep our course, any change in the force or direction of the current, instead of producing a change in direction which is determinate, will produce a change in velocity which is indeterminate, and therefore the equal spacing for intermediate soundings will give only an approximation to the truth. If, in addition, we are obliged to wait for our intersecting range to make the location, a great discrepancy may result, and the survey will be valuable only as a reconnaissance.

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This must be very apparent when it is considered that the velocity of the boat may be suddenly increased to twice or three times its original velocity, and as suddenly diminished to one-half or one-third of that velocity.

For the reduction of soundings, three tide-gauges have been kept: No. 1 at the brick-wharf, Galveston; No. 2 at the end of the breakwater, Fort Point; and No. 3 at the Government wharf, Bolivar. No. 1 has been kept most of the time since September 27, 1875, taking hourly readings from 7 a. m. to 5 p. m.; No. 2 has been kept only when soundings were being taken on the inner or outer bar; and No. 3 has been kept almost continuously since March 23, 1876, taking hourly readings, day and night.

Very little was done in the way of sounding for the large chart until May 15, 1876. From this time the work has progressed without important interruption, save from bad weather and the necessary delay occasioned by the launch having to make a 5-mile trip before and after each day's work.

The following exhibit will compare very favorably with a similar one for previous work, and will show what an immense advantage there is in having a steam-launch for this kind of work:

Number of square miles of hydrography	73
Number of linear miles of hydrography	400
Total number of soundings taken	19,200
Number of soundings per square mile	263
Number of hours actually taking soundings	95
Number of days in which soundings were taken	21
Average number of hours per day actual work	4½
Average number of days favorable for hydrographic work since May 15	1 in 2½

This last includes much time of inside sounding, which was not at all favorable for outside work.

The outfit and labor for this work consisted of a steam-launch, with captain and engineer, 1 leadsman, 1 time-keeper, 1 recorder, and 2 observers.

Below is exhibited the method of keeping the records:

Name of stations.	Angle, (sextant No. 1642.)	Time.	Soundings.	Name of station.	Angle, (sextant No. 1643.)	Remarks.
	Index error.	*h. m. s.*	*Feet.*	15″	*Index error.*	
	Zero	8 24 30	12.3		−0° 01 10″	Pole course E. by N.
			13.2			
△ A & △ B..	61° 34′ 40″	8 25 10	14.6	× △ B & △ C.	88° 03′ 20″	Hard sand line.
			16			
			16			
			16			
			16½	×		
			17			
		8 26 18	17½			Range △ G & △ H.
			19			
			20	×		
				30″		
Do	96 28 30	8 27 32	22	△ B & △ D.	76 22 50	
			23½	×		
			24			
			26	×		Soft mud.

In this way every material fact can be succinctly and intelligibly recorded. The cross-marks thus (×) indicate the sounding that occurred at the even minute. The figures inclosed thus 15″ 30″ indicate that the soundings following were taken once in 15 seconds or 30 seconds, as the case may be. Under the head of "remarks" should be noted every change of course or other information likely to be of value in plotting; and at the close of each day's soundings the lead-line should be carefully tested and its error noted.

CHANGES.

By reference to the charts, it will be seen that some remarkable changes in the shore-lines and channels took place during the storm of September; Pelican Spit was mostly swept away and its shape entirely changed. The eastern end of Galveston Island was cut through by two shallow channels and the general surface-level greatly reduced. Three-fifths of the pile-breakwater, of which there was 6,800 feet, was carried away. The knoll has been swept south of a line running east from the outer end of the gabion-jetty, and the swash-channel has been closed at its head, and its depth greatly reduced.

A new channel across the outer bar was made in the prolongation of Bolivar Channel; and for a width of channel of 5,000 feet extending from the 12-foot curve on the

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inside to the same curve on the outside, a mean depth of $\frac{9}{10}$ of a foot was attained, and from this area 1,194,000 cubic yards of material were removed. A channel of sufficient width for navigation, having a depth of 12½ feet at mean low-tide, was thus formed, which has been maintained up to this time and shows every indication of permanence. The old ship-channel, which until the storm was used by all deep-draught vessels, has become so obstructed that it is only used by those of light draught.

On the inner bar the changes were very marked. A new channel was cut through the bar in a line nearly direct from the end of the breakwater to the light-vessel, deepening the bar at this point from 7 to 12 feet and greatly reducing its width; while the old channel was not changed in depth, its width was reduced, so that the actual condition of the bar was not improved for navigation for vessels of deep draught. But the impetus thus given remained, and a gradual deepening of this new channel continued; and the next survey, made February 25 and 26, showed a depth of 14½ feet across the bar. March 24 there was 15 feet, and June 17 there was 16½ to 17 feet, and the distance across the bar from the 18-foot curves on either side was only 450 feet.

From the 18-feet curves in the Galveston Channel to the same curve in Bolivar Channel in June, 1875, covering an area of 1,412,833 square yards, which has been mostly affected by changes during the year, a mean depth of $6\frac{3}{10}$ feet has been attained, and 3,024,163 cubic yards of material have been removed.

I have been assisted during the year by Mr. R. B. Talfor, United States assistant engineer; Mr. Wm. Thompson, assistant engineer; Mr. J. C. Buchanan, assistant engineer; and Mr. Richard Scott, assistant engineer. Mr. Talfor has assisted in every portion of the work, both in field and office. Mr. Thompson has executed the topography and assisted in taking sections. Mr. Buchanan did most of the leveling for the determination of the high-water of 1867 and 1875; and Mr. Scott assisted in the hydrographic work for a short time, during Mr. Talfor's absence.

Very respectfully, your obedient servant,

H. C. RIPLEY,
Assistant Engineer.

Lieut. C. E. L. B. DAVIS,
Corps of Engineers, U. S. A.

The charts herewith, marked "A," "B," and "C," show the condition of the channel in course of improvement across the inner bar at the several times of survey.

The final chart, which is from a survey made about the middle of last June, shows an excellent channel of 16½ feet least depth at mean low-tide, or over 17½ feet at average flood-tide. The increase in depth obtained by the gabion structure has therefore been about 5 feet at the minimum, and the 18-foot contour-lines inside and outside the bar, which in 1873 were 5,690 feet apart, are now but 450 feet apart. This favorable change was observed in progress previous to September 14, and although no addition has since been made to the jetty, the change is apparently yet in progress. It only seems necessary, in order to deepen this channel to 20 feet, and secure it from injurious effects of storms, to extend the jetty but a short distance further and raise it near the water-surface.

For this purpose, and to utilize the fair-weather months of July and August, it was hoped that further appropriation might be available by the 30th of June.

Such appropriation as may be made it is hoped to use in completing the Fort Point jetty, and afterward in commencing the Bolivar Point jetty for improvement of the outer-bar channel.

It is recommended that the work be conducted as heretofore, and not by contract.

In closing, mention should be made of the gallant men who went to the rescue of the employés at Fort Point, who were cut off by the storm of September, and in great peril.

Assistant R. B. Talfor; Mr. R. M. Pease, overseer, who had himself just been rescued while drifting in the harbor; Capt. William M. Andrews, of the disabled tug Molyneux; Mr. Samuel H. Perkins, engineer of the same vessel, and others, whose names have not been given me,

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took possession of the steam-tug General Stewart Van Vliet, and with the captain and engineer of that vessel, and a volunteer life-boat crew composed of pilots and other citizens of Galveston, succeeded in bringing off all but two of the men left at Fort Point. Of the two missing, one was killed by the falling timber of the men's quarters, and the other drowned by being overweighted with clothing.

Lieutenant-Commander D. C. Kells, U. S. N., and the officers and crew of the United States gunboat Rio Bravo, reclothed and fed the half-drowned men on their arrival at the wharf.

These men saved, lost nearly all their personal effects, and are deserving remuneration, the more so as they waited until cut off, working to save Government property.

The work is located near the light-house on Bolivar Point, Texas, and that portion for improvement of the inner bar is, I think, capable of completion to give a permanent channel, while that designed for the outer bar, as heretofore reported, may require short extension from time to time.

The data for new estimates to cover changes in construction recommended by the Board are not yet sufficient for the purpose.

The estimates of last year are therefore left standing until such time as they may be well revised.

Money statement.

Amount available July 1, 1875	$141,951 49
Amount expended during fiscal year ending June 30, 1876	123,201 51
Amount available July 1, 1876	18,749 98
Amount appropriated by act approved August 14, 1876	142,000 00
Amount (estimated) required for completion of existing project	209,700 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	209,700 00

J 3.

IMPROVEMENT OF ENTRANCE TO GALVESTON HARBOR, TEXAS.

REPORT OF THE BOARD OF ENGINEERS.

ARMY BUILDING,
New York, December 28, 1875.

GENERAL: The Board of Engineer Officers, re-assembled by Special Orders No. 160, dated December 10, 1875, "to reconsider the question of the improvement of the entrance to Galveston Harbor, Texas, and the modifications, if any, to the plan adopted therefor, which may be advisable from the effects produced in the channels and shoals of the harbor and its entrance by the storm of September 15, 1875," having carefully reconsidered the subject, have the honor to submit the following

REPORT.

In the report of the Board, as originally constituted by Special Orders No. 9, of January 26, 1874, in regard to the improvement of the entrance to the bay and harbor of Galveston, it was recommended that two piers or jetties should be constructed, the more northern of which, starting from an indicated point on the Bolivar Peninsula, should be extended to the bar, as shown on the chart submitted with the report;

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the other starting from the end of the pile construction put down by the city of Galveston for the protection and with a view to the extension of the eastern end of the island, known as Fort Point, on which the city is situated. This second pier or jetty was to be extended toward the Bolivar Channel to a point to be decided by the effect produced during the progress of the work, and then to be turned, gradually, perhaps, toward the outer bar to a direction generally parallel to the jetty on the opposite or Bolivar side of the main channel.

These jetties were not necessarily to be brought above or even to the surface of the water through their entire length, but were to be what are known as training-walls, to direct the current flowing in and out of the bay, and more especially to arrest the sands which are carried along the coast by the currents flowing in both directions—currents due, as we learn from the observations submitted to us, mainly to the action of winds. With such training-walls, the Board believed that an important increase of depth of water upon the outer bar would be assured; and, moreover, that the inshore portion of the southern jetty leading toward the main or Bolivar Channel would, by extending the Fort Point extremity of Galveston Island, tend to re-establish the condition which existed when the entrance to what is known as Galveston Harbor had an asserted depth of 30 feet; or, in other words, when no bar existed at the entrance.

In making this recommendation there was a good deal which the Board considered and presented as tentative, and especially as regarded the direction of the portion of the southern jetty extending from Fort Point toward the main or Bolivar Channel, as also the height to which this portion should be raised; though the prevailing opinion was that it would be necessary to raise the larger part, if not all of this, above water.

Captain and Brevet Major Howell, a member of the Board, and the officer designated for the charge of the work, had presented a novel and cheap device for the construction of jetties like those in question, in which gabions, plastered inside and out with cement and filled with sand, were to take the place of the stone or concrete blocks hitherto used in such structures. The Board, impressed with the economy which would attend the use of this device, though less confident of its success than its originator, advised its trial, beginning at the inshore end of the Fort Point jetty; and, after a proper extension of this toward the channel, then an experimental length of from 300 to 500 feet on the outer bar on the Bolivar Point line of jetty, when a full test of the action of the waves on this novel structure would be obtained. Also, that the inshore end of this jetty should be commenced at the same time as the portion on the bar.

In pursuance of this recommendation, the work was commenced and carried out on the Fort Point side to the extent of about 1,200 feet, when the storm of September 15, 1875, occurred, which produced such changes in the channels and in the surface of the northern end of Galveston Island as to induce the re-assembling of this Board.

Before reciting the changes occasioned by this storm, it seems proper to state those produced by the works so far as they had been carried. These works, as before remarked, had been carried out from Fort Point about 1,200 feet toward the Bolivar or main channel, using in the construction the sand-filled gabions of Major Howell, and the northern end of Galveston Island had followed the construction, obliterating largely the "swash-channel" formerly existing around this point, while the shoal beyond, known as the "knoll," had been moved northward toward

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the main channel, and around the end of the jetty toward the entrance to the harbor of Galveston. As the sand of this shoal and of the bar to the harbor comes mainly from the drift occasioned by the currents and waves produced by the southwesterly winds, this action was to have been anticipated, and, moreover, it was likely to continue until the jetty should be prolonged sufficiently near to and far enough along the main channel, and be raised to such height, as to arrest this action.

The effect of the storm upon the jetty itself seems not to have been very important, though the velocity of the current which the storm occasioned undermined the gabions somewhat, and caused a settling of several feet. So far as the gabions themselves are concerned, they seem to have stood the test at least as well as any other mode of construction would have done. Upon the channel into inner harbor the effects of the storm, while marked, do not seem important as regards the plan of improvement; while beyond the outer extremity of the jetty the rapid outflow of the water from the bay carried off a part of the "knoll," which had, under the apparent influence of the jetty, increased to the northward toward the main channel, and moved it back to nearly its old position.

The effect seaward of the storm had been to open a new channel over the outer bar on the prolongation of the Bolivar Channel—that is, directly seaward—or rather to deepen the channel that formerly existed there, and to narrow and contort the old main channel over the outer bar, which was more to the southward. Probably this new channel will be gradually filled up to its old depth, and the old channel re-established under the superior effect of the drift from the northeast, which determines the position of the main bar to the southward of the line of direct outflow of the waters of Galveston Bay.

In addition to the effects of the storm, above noted, must be added those produced on the island of Galveston itself. The waters, piled up in the bay by the easterly and southerly winds of the first part of the storm, were driven out with great force when the wind had got round to the northwest, and the rise of the water was such as to flood the eastern extremity of the island, and, by the rapidity of the currents thus occasioned, to sweep off almost all the land above water, east of the city, and to carry away all the workshops and buildings established for the harbor constructions. The loss of property to the Government is considerable, and is further to be regretted as delaying the prosecution of the work, as it destroyed not only the buildings and workshops, but a large number of gabions which require time for their manufacture.

These details of the effect of the storm are not noted with a view to giving information to the Department, which is already in possession of all the facts, but to indicate that the Board have taken them into consideration in the conclusions to which they have arrived.

These conclusions are as follows:

1. That the two jetties or training-walls recommended in the report of January, 1874, will, if constructed, produce an important increase of depth over the outer bar.

2. That the portion to be first constructed should be that part of the west jetty starting from Fort Point toward the main channel, and continuing as far along the same as may be necessary in order to improve the inner bar, by preventing the transport of the sand by waves and currents into the inner channel, and allowing the currents of that channel to increase the erosion.

3. As the use of gabions is a novelty, and, consequently, as we have no experimental knowledge regarding their reliability for such works,

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they should not be adopted definitively for the main works until a more thorough and extended test shall have been made of them by the extension of the inshore-end of the Fort Point jetty, by constructing from 300 to 400 feet of the northern jetty on the most exposed position on the bar, and of a portion of the inshore-end of that jetty, as recommended in our first report.

It should be stated that, in the opinion of the Board, the use of these gabions in exposed situations can be attended with success only in case they shall be soon covered by the drifting sands, so as to protect them from injury from the continued action of waves, from the shock of floating bodies, and from all other causes which might tend to disrupt them and allow their sand-filling to escape. When so protected they will form a nucleus for the sand-ridges as stable and as permanent as if of stone or concrete. But if not so protected, these gabion structures will be constantly liable to injury and in time to decay, when, losing their sand-filling, the structure would soon be washed away. That the proposed jetties will be so covered seems probable, but can be determined only by trial such as we have recommended.

4. In the opinion of the Board the channels caused by the storm of September 15, last, across the island between its eastern point and the city, should be closed, the mode of doing it being left to the judgment of the officer in charge.

5. It is further suggested that in future work the gabions be placed on mats previously sunk on the bottom and properly weighted, instead of upon the sand; these mats to extend not less than about 8 feet beyond the jetty, both on the front and back, and that these mats be laid so far in advance of the jetty as to prevent the scour which will otherwise occur around the jetty-head.

From the foregoing it will be seen that the Board do not consider that any modifications of the original project are advisable in consequence of the effects of the late storms, and that they think the trials recommended in their original report, which had been only partially carried out when the storm which compelled the cessation of work occurred, should be continued to completion.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers, Bvt. Maj. Gen.
H. G. WRIGHT,
Lieut. Col. of Engineers, Bvt. Maj. Gen.
JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Maj. Gen.

While in the main agreeing with the other members of the Board, I have to add that I find no reason for modifying the views advanced in my last annual report on this work, and in my report of the 13th of last October.

C. W. HOWELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

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J 4.

IMPROVEMENT OF THE RED FISH BAR IN GALVESTON BAY, TEXAS.

Contract for this work was awarded Mr. E. W. Cave, president of the Buffalo Bayou Ship-Channel Company, as reported last year.

Mr. Cave commenced the work, with due activity and with abundant means and suitable plant, on the 14th of August, 1875, and prosecuted it with energy until the 14th of September, when his dredging-fleet, with the exception of the United States dredge, which he had been permitted to use until called for under contract for Sabine Pass, was wrecked during the cyclone of that date. Work was re-commenced November 16, 1875, and steadily prosecuted until the appropriation was exhausted, when, under his contract for a ship-channel through Galveston Bay, &c., to be hereafter reported, the channel made was extended at both its upper and lower ends into the upper and lower bays.

This improvement, forming, in fact, a portion of the ship-channel through Galveston Bay, &c., and as both works were awarded to the same contractor and prosecuted by him simultaneously, it was not found possible after the cyclone, which destroyed all our landmarks, to keep account of the two entirely separate. The total length, with the width and depth of cut, of the associated works will therefore be given in the report of work on "ship-channel," &c.

In making payment on the work, a sufficient number of cubic yards of material excavated was assigned to the bar work to just absorb the balance of appropriation.

The following is the statement as given on voucher taken:

Fourteen thousand one hundred and thirty-three cubic yards of material excavated with United States dredge-boat and placed on side of cut, at 17 cents; 23,735⅓ cubic yards of material excavated with contractor's boats and carried off on scows, at 25 cents.

The work is located in the collection-district of Galveston, near the light-house on Red Fish Bar, and gives some evidence of permanence, due to the flux and re-flux of the tides, which cause strong currents back and forth through it.

Importance of the work in a commercial point of view will be given in the report on the ship-channel, &c.

Money statement.

Amount available July 1, 1875	$9,760 22
Amount expended during fiscal year ending June 30, 1876	9,760 22

J 5.

IMPROVEMENT OF THE SHIP-CHANNEL BETWEEN THE MOUTH OF THE SAN JACINTO RIVER AND BOLIVAR CHANNEL, IN GALVESTON BAY, TEXAS.

This work was commenced under contract with Mr. E. W. Cave, president Buffalo Bayou and Ship-Channel Company, (reported in my last annual report,) about August 28, 1875. Its completion, so far as the amount of appropriation would permit, was delayed by the cyclone of September 14, 1875, as reported in regard to the work for improvement of Red Fish Bar. Notice was given on the 7th of February, 1876, that appropriation was exhausted and the contract closed. Since that time

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the contractor and other private parties interested in the continuance of the work to completion have carried the work forward to an extent not well known to me, but which up to the time of relief of my inspector was reported by him as amounting to the removal of 4,832$\frac{24}{25}$ cubic yards of material from the channel on the proposed line of its extension.

The amount of excavation paid for by the United States is shown as follows: 27,024½ cubic yards of material excavated with United States dredge-boat and placed on side of cut, at 17 cents. Seventy-seven thousand eight hundred and ninety-six and nine twenty-fifths cubic yards of material excavated with contractor's boats and carried off on scows, at 25 cents. This, with the work for improvement of Red Fish Bar, has made a continuous channel through the bar, and above and below it in Galveston Bay, as shown by the accompanying chart and cross sections.

The channel dredged is 6,100 feet in length and has a minimum depth of 14¼ feet at mean low-tide.

It connects depths of 9 feet and 8½ feet in the upper and lower bays, and, with the private work of improvement at Morgan's Point, permits the passage of vessels of 9 feet draught to within a few miles of Houston, Texas, with which it is designed to connect it by a short railroad now reported in course of construction.

The first inspector of the work was Professor C. G. Forshey, assistant engineer, who was shortly after assigned to more important duties, and was succeeded by Capt. Abram Cross, assistant engineer. After the cyclone, Captain Cross was placed on work of survey at the mouth of the Mississippi, and General Albert G. Blanchard, assistant engineer, was appointed inspector, which position he retained until the close of the work.

Use of the United States dredge, allowed the contractor, was given, on condition that he should haul the boat out on the ways at Morgan's Point, thoroughly repair her hull, and, when called upon to do so, return her to Galveston in good working-order.

It was further stipulated that the work done by this dredge should only be paid for as provided in his original bid, that is, one cent lower per cubic yard than for the work of other dredges.

The conditions were faithfully observed, the hull being repaired, at considerable expense, and repairs to machinery, on return of boat, paid for to the amount of nearly $500.

The commercial importance of the work has been shown in previous reports, to which the following is added:

NEW ORLEANS, *July* 20, 1876.

DEAR SIR: In response to your letter of 7th instant, making inquiry respecting the progress of the work on the ship-channel in Galveston Bay since the termination of the United States Government contract at Red Fish Bar; also the present condition of navigation at the terminus near Houston; the advantages that have so far accrued from this work, on and near Red Fish Bar; also if there has been noticed any deterioration in the channel dredged there and below Morgan's Point, we beg to state:

The channel is now dredged through Red Fish Bar, commencing in 10 feet water, soft bottom, on southeast side, running northwest 1 mile, with a depth of 14 to 20 feet, by a width of 200 feet.

This carries it into 8½ feet hard bottom; thence it is dredged northwest 2,000 feet, 14 feet deep by 100 feet wide, terminating in 9½ feet water. A strong current flows through the channel excavated, and at a straight line for some distance beyond. The scouring-force of the current is ample to maintain the channel. The steamships of the Morgan Line have navigated it with ease. There has been no decrease of depth on any portion of the work, and there is every indication of its being permanent. There is in the center of the Shell Reefs a natural basin about 2,500 feet long, and from 100 to 150 feet wide, with a depth of 15 to 30 feet. This basin is on the line of the channel excavated under contract with Captain Howell, and forms a part of it. The channel excavated in Galveston Bay, south of Morgan's Point, now extends as far as 9½ feet

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water in the bay. The entire length of deep-water channel from the San Jacinto River to 9½ feet water in the bay, is 4¾ miles.

The width of the channel through the land at Morgan's Point is 180 feet; that of channel in the bay, 120 to 150 feet; the depth of channel is from 13 to 17 feet. The course of the current is regular until it reaches the end of the work in the bay; and the effect of the scour is marked for a considerable distance beyond that point. During the cyclone of September last the water of Galveston Bay rose 10½ feet above average tide.

The current swept through the channel with great force. The effect was a general deepening along the whole line. Soundings made after the cyclone, both in the ship-channel at Morgan's Point, and at Red Fish Bar, demonstrated that on no portion of the line was there any decrease of depth. There is every reason to believe that when the bay from Bolivar Channel to the United States Government ship-channel through Red Fish Bar, and to the terminus of the ship-channel in Galveston Bay, south of Morgan's Point, is deepened to 12 feet, the work will remain open. On the line of extension of the work, the least depth of water is 8½ feet. Experience in these bays has shown that at such depth the bottom is not disturbed by action of waves during ordinary storms; and it is, therefore, believed that the channel will not be affected from such cause. There is now unobstructed navigation for vessels drawing 9 feet water, from the Gulf of Mexico, via Bolivar Channel, to Clinton, the point of railroad connection with Houston, on Buffalo Bayou, 6 miles from that city. From Morgan's Point to Clinton, the San Jacinto River and Buffalo Bayou is from 25 to 14 feet deep. The width is from 200 to 400 feet. The first steamship navigating the ship-channel was the Clinton, of the Morgan Line, with cargo, drawing 9½ feet water, April 21, 1876. The schooner Robert Ruff, with cargo, drawing 9 feet 8½ inches, was the first deep-draught sail-vessel navigating the channel, May 3, 1876. Both vessels passed through the United States Government ship-channel at Red Fish Bar, the schooner Robert Ruff being under sail.

The passage from the Gulf to Clinton was made without delay. Since that time the ship-channel has been in use by both steam and sail vessels, and its success is fully demonstrated. Clinton, the point of railroad transfer to Houston, was named in honor of the steamship Clinton. Ample wharves have been built at this point, and a railroad built affording through connection with the whole railway system of Houston. The Bayou at Clinton is 210 feet wide and from 14 to 18 feet deep.

Simms's Bayou, which empties into Buffalo Bayou, here affords a natural turning-place for ships. The passage from the Gulf to Clinton is made by steamships in about 5 hours.

The completion of the 12-foot ship-channel through Galveston Bay the present year would open to the coastwise trade of the United States communication with the railroads of Texas centering at Houston.

The depth of the Galveston outer bar being but 12 feet, nearly all foreign vessels receive their cargoes in the Gulf from lighters. These lighters are engaged in the trade of both Houston and Galveston. Barges are employed in the lighterage business of Houston. An elevator has recently been built at Houston. Vessels engaged in carrying grain to coastwise ports will be enabled to take their cargoes on Buffalo Bayou when the channel is completed.

A large surplus of wheat and oats will seek this outlet the present year; and upon the present draught of water considerable shipments will be made to New Orleans from the railroad connection near Houston.

The opening of this channel will shorten the line of railroad-carriage on all coastwise freights 43 miles. It secures post facilities that distance in the interior of Texas, and for grain-shipments to Atlantic ports presents great advantages. It will secure a great saving in the cost of freights destined for the interior of Texas and for Houston, and a corresponding saving in cost of shipments of agricultural products.

The steamships of this line now engaged in the trade with New York are compelled to re-ship their Texas cargo via Morgan City. With a draught of 12 feet water, a profitable trade will be carried on direct from New York to Houston.

The lines now engaged in the direct trade between Galveston and New York deliver their interior Texas freight at Galveston, from whence it is shipped, via Houston, to interior points. The cost of freight from Galveston to Houston, via rail or steamboat, is 40 cents per barrel, and $1 per bale on cotton.

Vessels running direct from Atlantic ports in the trade of Houston would now be compelled to lighter their cargoes in Bolivar Channel. The completion of the 12-foot channel will save the cost of this trans-shipment. The present head of ship-channel navigation is within 6 miles of Houston, at Clinton. A railroad is built from this point to the center of business in Houston, connecting with the great lines penetrating the State.

Facilities are provided for the rapid handling of freight to Houston, and all through-freight will be transported to and from shipping without breaking bulk. The steamships of this line have navigated the ship-channel from the Gulf, via Bolivar Channel, to Clinton, since April 21, without difficulty; draught, 9½ feet. Sailing-vessels drawing

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9 feet 9 inches have also made the voyage to Clinton. The work through Red Fish Bar is now completed, with a depth of water greater than that on the Galveston outer bar, and all information furnished us leads to the conclusion that when the channel is opened through the bay to a depth of 12 feet, it will be permanent.

The number of bales of cotton shipped out of Galveston Bay of the last crop is 460,000. Of this about two-fifths was transported from Houston via Buffalo Bayou. The number of vessels engaged in the coastwise trade which entered at Galveston, the port of Galveston Bay, for the six months ending March 31, 1876, was:

Steamers, 170—number tons	210,378
Sailing-vessels, 64—number tons	23,642
Total tons	234,020

American and foreign vessels engaged in foreign trade entering and clearing, same period:

American vessels, 39—number tons	22,578
Foreign vessels, 107—number tons	63,273
Total tons	85,851

The completion of the 12-foot channel will afford facilities for the tonnage above named engaged in the coastwise trade, and the foreign tonnage of that draught of water to reach the railroad system of Houston. The steamships of this line secure return-cargoes of cattle for New Orleans and Havana at Clinton.

There is now a large lumber trade between the Louisiana, Alabama, and Florida coast and Galveston Bay for the supply of interior Texas. That, with the Florida coast, will be greatly facilitated by the completion of the 12-foot ship-channel. It is anticipated that a large grain business will be opened between Houston and Atlantic ports upon the completion of the 12-foot ship-channel.

It is our expectation to place steamships in the direct trade between New York and Houston when 12-foot navigation is secured in Galveston Bay.

Some little delay has occurred in securing the data required by you, for which we beg to apologize, and remain

Very truly, yours, &c.,

CHAS. A. WHITNEY & CO.,
Agents.

Capt. C. W. HOWELL,
Corps of Engineers, U. S. A.

It cannot be certainly stated if the work may be one of permanent character or not.

It is recommended that any appropriation that may be made for the present year be applied in making, under contract, a 12-foot channel in extension of the channel reported, and that the upper terminus of the channel be made at the cut through Morgan's Point instead of at the mouth of the San Jacinto River.

This change of line through the upper bay, together with the practical demonstration given us, that the work of dredging can be done for 30 cents or less per cubic yard, without taking into consideration the work already performed by private parties, permits a reduction of estimate as follows:

For completion of 9-foot cut through bar, 34,000 cubic yards excavation, at 30 cents	$10,200 00
For a 12-foot channel from Bolivar Channel to Morgan's Point, 2,171,874 cubic yards excavated, at 30 cents	651,562 20
For a 15-foot channel from Bolivar Channel to Morgan's Point, 4,200,207 cubic yards excavated, at 30 cents	1,260,062 10

Should the line through the lower bay be changed so as to make the channel enter the head of Galveston Harbor, an increase of estimate will be called for.

The work is located in the collection-district of Galveston near the light-house on Red Fish Bar.

The amount appropriated for the present year, when made available, it is proposed to expend, under contract, in continuation of the ship-

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channel between Red Fish Bar and Morgan's Point, if the recommendation to terminate the channel at that point be approved. Otherwise, to continue a 12-foot channel from Red Fish Bar toward the mouth of the San Jacinto River.

Money statement.

Amount available July 1, 1875	$25,000 00
Amount expended during fiscal year ending June 30, 1876	25,000 00
Amount appropriated by act approved August 14, 1876	72,000 00
Amount (estimated) required for completion of existing project	554,560 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	250,000 00

J 6.

IMPROVEMENT OF SABINE PASS, TEXAS.

Under the act of Congress approved March 3, 1875, appropriating $20,000 for this work, it was duly advertised for contract, and bids received as shown by the following synopsis:

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Abstract of bids received for the improvement of Sabine Pass, Texas.

Number.	Bidders.	Residence.	Guarantors.	Bidders furnishing dredge, tug-boats, scows, and labor, and providing for agent.		United States furnishing dredge; bidder furnishing all other boats, &c.		Time of commencing work.	Remarks: Number of dredges, tug-boats, scows, &c., to be furnished.
				For excavation carried off on scows, per cubic yard.	For excavation placed on side of cut, per cubic yard.	For excavation carried off on scows, per cubic yard.	For excavation placed on side of cut, per cubic yard.		
1	S. N. Kimball	Mobile, Mobile County, Ala.	D. R. Dunlap and T. N. Fowler, Mobile, Mobile County, Ala.	$0 45	.....	$0 38	.....	On or before Jan. 10, 1876.	1 dredge, 2 scows, 1 tug-boat.
2	J. E. Slaughter	....do	L. Scranton and J. C. Chamberlain, Mobile, Mobile County, Ala.	39¾	.....	33¾	.....	On or before Dec. 31, 1875.	1 dredge, 2 scows, and 1 tug-boat.
3	Thomas J. Sternbergh	Lawrence, Douglass County, Kans.	Darwin F. Frazell, Columbus, Colorado County, Tex., and Adolph Flake, Galveston, Galveston County, Tex.	33½	.....	28	.....	.....	November 1, 1875, with own dredge; September 15, 1875, with United States dredge; 1 dredge, 2 scows, 1 tug-boat.
4	Curtis, Fobes & Co.; John D. Curtis, Charles Fobes, Geo. C. Fobes, Lamartino J. Fobes, all of Portland, Me.	Portland, Cumberland County, Me.	Leander W. Fobes and Henry H. Burgess, Portland, Cumberland County, Me.	.....	.....	12½	.....	On or before Oct. 1, 1875.	1 dredge, 2 scows, 1 tug-boat.

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Contract was awarded to Curtis, Fobes & Company, of Portland Me., they being the lowest responsible bidders.

The conditions of their bids were that they should be allowed the use of the United States dredge belonging to the work of "improvement of Galveston Harbor," which was no longer required on that work, to be placed at their disposal in good working-order, and at conclusion of contract returned in the same order; that the work should be commenced on or before the 1st day of October, 1875, and be prosecuted with due diligence until exhaustion of appropriation.

Owing to difficulty of securing tug-boat and scows, (as I am informed,) the contractors were not able to commence work on the Sabine Pass Bar until the latter part of February, 1876.

The delay was not, however, material, as it covered a portion of the most difficult season of the year for work at Sabine Pass.

Since commencement the work has been prosecuted apparently in the best of faith, but under very discouraging circumstances. Once the scows were reported driven ashore during a storm, and much delay is reported as due to breakage of machinery, which, owing to the distance of the work from Galveston, the nearest point of repair, gave much trouble.

The work done up to June 30, 1876, is shown in the following table

Amount of excavations at Sabine Pass, Texas.

1876.	Cubic yards.
March 1	4,014
March 1 to 9, inclusive	3,535
March 9 to 31, inclusive	881
May 3	5,018
May 31	3,850
June 30	5,996
Total	23,294

On this first installment of $1,000 has been paid.

It will be seen from this that the work has not progressed far enough to give evidence on which to base any conclusion different from that given in my last report relative to permanence.

It is proposed, as stipulated in the contract, to continue the work as at present until the appropriation is exhausted.

Estimates for completion of the work, as made in report of February 4, 1875, are resubmitted.

For a channel 12 feet deep, 291,713 cubic yards excavation, at 30 cents per cubic yard	$87,513 90
For a channel 15 feet deep, 489,087.66 cubic yards excavation, at 30 cents per cubic yard	146,726 30
For a channel 20 feet deep, 1,084,214.66 cubic yards excavation, at 30 cents per cubic yard	325,264 40
Add to each 20 per cent. for contingencies, makes in round numbers:	
For a channel 12 feet deep	105,026 00
For a channel 15 feet deep	176,071 00
For a channel 20 feet deep	390,317 00

	Miles.	Feet.
Length of 12-foot channel	2	2,625
Length of 15-foot channel	2	4,810
Length of 20-foot channel	4	2,505

Probable time required to complete the work, under the following assumptions:

First. That appropriation is made, so as to make the work continuous.

Second. That three Morris & Cummings's dredges are employed, with

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a sufficient number of dump-flats and tug-boats to enable each dredge to work up to 2,000 cubic yards each working-day of ten hours.

Third. Allowing one-half time lost on account of repairs, stormy weather, and Sundays.

	Days.
For 20-foot channel	360
For 15-foot channel	163
For 12-foot channel	48

The cost of maintenance of the channel can only be ascertained from experience on the work.

The work is located in the collection-district of Galveston, near the light-house at the entrance to Sabine Pass.

Commercial statistics for the year have not been received.

The appropriation of August 14, 1876, was made to cover several distinct works, namely, Sabine Pass, Blue Buck Bar, and Sabine Bay, and for deepening the channel over the bar at the mouth of the Sabine River, and for deepening of the channel over the bar at the mouth of Neches River, where these rivers enter Sabine Bay.

Should the appropriation, when made available, be divided up among these several works, it will do no appreciable good to any one of them. It is therefore recommended that the whole be applied to Sabine Pass, to continue the work now in progress, and that work under it be done by contract.

Money statement.

Amount available July 1, 1875	$20,000 00
Amount expended during fiscal year ending June 30, 1876	3,341 16
Amount available July 1, 1876	16,658 84
Amount appropriated by act approved August 14, 1876	38,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	29,500 00

APPENDIX K.

ANNUAL REPORT OF CAPTAIN W. H. H. BENYAURD, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., July 1, 1876.

GENERAL: I have the honor to transmit herewith annual reports upon the works under my charge, for the fiscal year ending June 30, 1876.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

K 1.

IMPROVEMENT OF THE OUACHITA RIVER, LOUISIANA AND ARKANSAS.

Operations during the year were continued with the snag-boat O. G. Wagner, in charge of Justin Straszer, assistant engineer, in clearing the river of the most dangerous obstructions.

As Bayou Bartholomew needed some improvement, and being the

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most important tributary of the Ouachita, and navigated by the same steamers, I directed that the "Wagner" be taken into that stream for a short time. It was found, however, that the stage of water was such as not to admit of any permanent improvement without a considerable expenditure of money. Accordingly the boat was withdrawn from the bayou, and its operations confined to the Ouachita. At the close of the season, being in need of certain repairs, she was taken to New Orleans, docked, and put in thorough order, ready for operations during the coming season.

For the operations upon the Ouachita River, Captain Straszer reports as follows:

Operations on Ouachita River were commenced on the 3d day of June, 1875, and continued until the 21st day of August; resumed again on the 21st day of December, 1875, and closed on the 4th day of February, 1876.

The projects of improvement contemplated the removal of snags and logs from the river-bed, the cutting of overhanging timber along the banks, the removal of the wreck of the steamboat Lotawanna, and the extraction of the remaining piles of the bridge piers of a destroyed railroad bridge in front of the wharf-boat at Monroe, La.

The work of removing snags and logs from the channel was carried on between Camden, Ark., the present head of navigation, and Columbia, La., a distance of 226 miles.

Owing to the continuous high stage of water, no work could be done between Columbia and Trinity.

During the whole season the stage of water was very fluctuating, hence it was deemed advisable to adopt the plan of patrolling the river, and work above or below certain localities, in accordance with the rise and fall of the river.

The principal places where the channel was cleared of obstructions are: Yeager's Towhead, Spoon Camp, Haidee, Romeo, Horse Head, Franklin, and Paroquet Shoals, in the State of Arkansas; and Loch-Lomond Shoals, Des Oeuf Bend, Two-Paw Shoals, above Monroe, and that portion of the river extending from Monroe to Cuba, in the State of Louisiana, a distance of 30 miles. Several of these places had to be revisited at different times, the operations having been interrupted by either too high or too low water. Isolated snags and cypress butts (so-called "sawyers") were found in almost every bend and shoal, and destroyed.

The number of snags destroyed and removed from the channel amounts to 653; number of overhanging trees cut, 835; wrack-heaps destroyed, 6.

The wreck of the stern-wheel steamboat Lotawanna, sunk below Grand Marais Landing, in Arkansas, 8¼ miles above the State line, was a serious obstruction to low-water navigation. The most dangerous portions of the wreck, consisting of parts of her machinery, were removed; and the forward part of her hull, which reached out into the low-water channel, was blown up with gunpowder. The wreck was visited twice, the suspension of the operations on that object having been caused by the breaking of an essential part of the hoisting-machinery of the boat.

The obstructions in front of the wharf-boat at Monroe, La., consisted of the piling of the piers of a destroyed railroad-bridge. An attempt to remove them was made with the crane-boat Ouachita during the season 1873, which proved useless, as the equipment and the hoisting-power of that boat were insufficient to achieve any success.

These piles were set in clusters and connected with heavy sills capped and mortised to the heads of the piles. Eight of these sills were pulled off and 30 piles extracted, which were found by subsequent measurement to have been driven into the ground from 16 to 17½ feet. This formidable obstruction is now entirely removed, leaving a clear channel in front of the wharf-boat.

BAYOU BARTHOLOMEW.

By your orders, dated Memphis, Tenn., December 13, 1875, I was instructed to extend the operations also to Bayou Bartholomew, the most important tributary of the Ouachita River.

Upon entering that stream I observed during the first few days' work that, with the ordinary working-force of the snag-boat, the progress in removing obstructions would be but very slight, and hardly perceptible in view of the enormous quantity of work which is needed in order to facilitate and improve navigation in that stream.

Having represented to you the facts in my special report dated January 9, 1876, I received your orders to discontinue work in the bayou.

The operations in the bayou were confined to that portion extending from the mouth to Point Pleasant, a distance of 40 miles, working 12 days; and during that time the following-described work was executed: Pulled 91 snags; cut 339 overhanging trees;

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removed 2 wrack-heaps, and the rudder-posts and fan-tails of the hull of steamer Big Horn, lying about 16 miles above the mouth of the bayou.

During the coming season it is proposed to continue operations with O. G. Wagner.

The original estimate of operating upon the Ouachita with snag-boat was as follows:

Cost of steamer	$30,000 00
Running-expenses, per month	2,200 00

Money statement.

Amount available July 1, 1875	$18,485 49
Amount expended during fiscal year ending June 30, 1876, (Louisiana, $15,728.08; Arkansas, $2,399.38)	18,127 46
Amount available July 1, 1876	358 03
Amount appropriated by act approved August 14, 1876	12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	30,000 00

K 2.

IMPROVEMENT OF THE YAZOO RIVER, MISSISSIPPI.

The amount appropriated for the Yazoo River being very small ($12,000) in comparison with the work absolutely required to be done, it was not deemed advisable to expend any part of this amount in an outfit intended expressly for operation in this river, but endeavor to obtain as good a result as possible with the limited means at disposal; and, as the snag-boat O. G. Wagner could be spared for a short season from the Ouachita, advantage was taken of this, and authority asked for and obtained to operate her in the Yazoo.

The following, from the report of the assistant engineer in charge, Mr. Justin Straszer, gives the extent of the operations in the Yazoo:

Having received your verbal instructions relative to the extent of operations in Yazoo River, I started with the snag-boat from Vicksburgh on the 2d day of September, and commenced active work on the 3d of September, 1875.

The back-water of Mississippi River, which extended at that time far above Yazoo City, in conjunction with a head-rise, prevented any operations between the mouth of the river and the foot of Honey Island, and I concluded to proceed to the head-waters of the river and operate down stream with the receding stage of the water. Upon the special request of the steamboat owners plying in Yazoo River and its tributaries, I was authorized to remove the most dangerous portions of the wreck of steamer Star of the West, lying across the channel in Tallahatchie River, 6 miles above the junction of the latter stream and Yallabusha River. After working a short time at the wreck, it was apparent that without the aid of a submarine diving apparatus all attempts of meeting with success would be useless, and I abandoned the wreck in expectation that the outfit of the boat would shortly be augmented with the proper apparatus to enable me to work at that class of obstructions with advantage and to secure their removal.

The operations in removing snags and logs from the channel, and the cutting of overhanging timber, were carried on from the junction of Tallahatchie and Yallabusha rivers, forming the Yazoo, to Hayne's Bluff.

Such obstructions were removed at the following-named principal localities:

French Bend and Erskine's Landing, Lower Egypt.

In bend at the head of Honey Island, Eagle Lake, and Ship's Landing.

From mouth of Short Creek to Session's Landing, distance one mile.

Bend above Wilson and Srew's plantation.

From O'Neal's Creek to Richard's Bayou, including Holly Bend, a distance of 3¼ miles.

From Lake Dick Landing to mouth of Big Sunflower River, distance 4 miles.

Clark's Landing.

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Brown's Bar, 1 mile below mouth of Little Sunflower River.

A great number of isolated snags were removed in different localities.

Owing to the fluctuations in the stage of water, these places were visited at different times. A large number of these obstructions consisted of land-slides, trees which slid off the banks, remaining in their upright position, far away from the banks in the channel, thereby narrowing the width of the channel so much that in several instances it was with great difficulty that the steamboats could effect a passage through these so-called "narrows."

These slide-trees are generally very heavy to pull, and require much time and work, as much as two days' work having been employed in the removal of single slide-trees in several instances, requiring the rigging up of heavy purchases on shore to aid the hoisting machinery of the snag-boat.

Heavy rains at the headwaters of Tallahatchie and Yallabusha Rivers kept the stage of water in Yazoo River far above the regular boating stage for that season of the year, hence it was difficult to get hold of certain obstructions which were considered dangerous to navigation in low-water season, their removal being especially desired by the pilots on that river.

Having represented to you in my special report, dated September 18, 1875, and also verbally the difficulties which were experienced at the different objects of work, occasioned by the character of bottom, the muddy water of the river during its continued high stage and other local influences, and advocating again the employment of a diving outfit as essential to secure success and meet the exigencies in certain localities, the snag-boat was then supplied with the above-desired apparatus. Owing to some delay in the shipment, it arrived on board the boat only a short time before closing the operations in Yazoo River, but, with the aid of the same, very important obstructions were removed which otherwise could not have been touched at all.

Work was resumed at the wreck of the "Star of the West," and the principal portions of it forming obstructions, namely, the larboard iron wheel, walking-beam and rudder-stock, removed, and the larboard gunwale, aft of the wheel, blown out with gunpowder, thus gaining 50 feet of channel width at low-water.

The shaft of the steamer Capitol, near Liverpool Landing, was taken out and dropped at the bar off the steamboat channel.

On account of the rapid rise in the river, operations were suspended on the 9th day of December, 1875, and the snag-boat was withdrawn from Yazoo River.

The following is the summary of work done from September 3 to December 9, 1875:

Pulled 512 logs and snags; cut 903 overhanging trees; destroyed 4 wrack-heaps; removed portions of the wrecks of steamers Star of the West and Capitol.

If the improvement be continued, it is intended to operate in the same manner in the Yazoo River during the coming season.

As the steamers navigating the Yazoo do not confine their operations to that stream alone, but also navigate the other tributaries, such as the Big Sunflower, Tallahatchie, &c., and which are equally important to have improved if the main river be, I would respectfully suggest, in the event of future appropriations, that the benefit thereof be extended to these tributaries.

For the Yazoo River proper the following is the original detailed estimate for the improvement. In case the other be included, detailed estimates can be submitted.

The cost of executing the work required on the river, including cutting overhanging trees, I estimate by each description of boat to be as follows:

BY IRON STEAMBOAT.

Cost of iron steamboat		$45,000 00
Two seasons' work, six months each, at $2,700 per month		32,400 00
Removing eleven wrecks		30,000 00
		107,400 00
Engineering and contingencies 10 per cent		10,740 00
		118,140 00
Deduct value of steamboat after four years' service		30,000 00
		88,140 00

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BY WOOD STEAMBOAT.

Cost of steamboat	$35,000 00
Two seasons' work, six months each, at $2,700 per month	32,400 00
Removing eleven wrecks	30,000 00
	97,400 00
Engineering and contingencies	9,740 00
	107,140 00
Deduct value of steamboat after four years' service	10,000 00
	97,140 00

BY CRANE-BOAT.

Removing snags and leaning trees only:

Cost of crane-boat	$7,000 00
One boat for workmen's quarters	700 00
Three seasons' work, six months each, at $2,200 per month	39,600 00
	47,300 00
Engineering and contingencies, 10 per cent	4,730 00
	52,030 00

The fourth class of obstructions are the overhanging trees. I submit estimate for their removal:

Two boats fitted up complete, with accommodations for workmen	$1,500 00
Tools, &c	500 00
Six months' work, at $1,500 per month	9,000 00
	11,000 00
Engineering and contingencies	1,100 00
	12,100 00

By appropriating $120,000, extending over a period of 4 years, a thorough improvement would be made on the river, which would be sufficient for many years to come.

Amount appropriated	$12,000 00
Amount expended	12,000 00

Money statement.

Amount available July 1, 1875	$11,616 47
Amount expended during fiscal year ending June 30, 1876	11,616 47
Amount appropriated by act approved August 14, 1876	15,000 00
Amount (estimated) required for completion of existing project	93,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	50,000 00

K 3.

REMOVAL OF RAFT IN RED RIVER, LOUISIANA.

In the month of July last work was continued, as in the previous month, with one crane-boat and a full force, under the direction of Capt. J. S. Tennyson, in local charge, felling timber above the head of the raft, in the vicinity of Spring Bank, to prevent the same from falling into the river and forming obstructions, the steamer Sterling being used in supplying the parties and in towing the crane-boat to such places as needed.

About 1,278 trees were felled during the time the force was employed.

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Afterward, toward the end of the month, the boats were all laid up at Shreveport, with the exception of the "Aid," which was then on its way to Mound City to undergo needed repairs.

Work was suspended until November, when the steamer Thomas B. Florence was purchased to take the place of the "Sterling," worn out in service. Owing to the continued low-water in Red River, the "Florence" did not reach Shreveport until the latter part of December, where she was detained some little time undergoing repairs and alterations.

In January the "Florence" and one crane-boat were again put into service, with full working-force, in the raft region, cutting leaning trees and timber likely to cave into the river, breaking jams, pulling snags, &c. During the month 2,107 trees were cut down; 32 jams were removed, the total length of which was 6,000 yards; pulled 5 snags, and sawed up 42 long trees.

Operations were continued during the months of February and March with the same working-force; 2,785 trees were cut down, 28 jams were removed, 250 square yards, surface measurement, from old raft were removed, and also 515 cubic yards of earth taken from tow-heads, and removed 14 large stumps from channel of river.

For the last two seasons the work upon the raft has been confined principally to keeping the channel (which had been opened through the entire length of the raft) clear of running drift, and thus prevent the reformation of the raft and the blockade of the river, and in cutting down the timber on the banks so as to prevent the same from falling into the river and causing obstructions, and at the same time to facilitate the cutting of the banks by the current, to widen the stream. Some work also was done toward removing certain portions of the old raft still remaining.

The following table will give approximately the present condition of the raft, width of channel, &c.:

Number of raft.	Number of tow-heads connected with raft.	Length of raft in feet.	Width of raft in feet.	Width of channel in feet.	Number of raft.	Number of tow-heads connected with raft.	Length of raft in feet.	Width of raft in feet.	Width of channel in feet.
1	10	1,800	85	190	(*)	1	1,000	140	110
2	1	.....	.....	140	20	.....	400	125	125
3	.....	300	75	125	21 and 22	.....	.....	.....	200
4	.....	275	60	110	23	2	800	100	105
5	1	250	60	100	24	1	.....	.....	135
6	1	200	75	110	25	5	900	170	120
7	1	300	75	110	26	4	1,500	200	120
8	4	250	75	100	27	3	1,800	215	100
9	1	150	80	110	28	2	2,000	240	110
10	2	400	75	125	29	.....	.....	.....	150
11	3	250	60	110	30	.....	.....	.....	150
12	1	.....	.....	125	31	3	400	130	100
13	1	275	80	120	32 to 37	.....	.....	.....	130
14	4	250	70	110	38	.....	400	125	125
15	4	1,000	100	110	39	2	900	135	125
16	3	1,500	100	115	40	.....	.....	.....	150
17	2	300	75	110	41	.....	300	140	115
18	3	500	95	110	42	.....	.....	.....	250
19	1	250	100	125					

*Above Gilmer, (no number.)

Channel-width is given for high-water from raft to shore.

It will be seen from the above that a considerable portion of the old raft still remains. The channel originally cut through the raft has

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been somewhat enlarged by the cutting away of the banks, but it is still too contracted. While it is not particularly desirable to remove the whole raft, as in many places the channel now formed would be injured, it is deemed necessary to remove certain portions of the raft-matter to better enable us to prevent the formation of jams, which occur regularly each high-water season, and which, if not removed, would soon occasion a re-formation of the raft and complete blockade of the river. The presence of a steamer for the express purpose of breaking up these jams is required constantly. They are formed or caused by the floating timber (which, during the higher stages of water, runs in immense quantities) lodging at the heads of the raft, and finally swinging around across the channel.

Now, if the shape of the heads of the rafts were made to conform more to the natural course of the current, so as to prevent the lodgment of the drift and to make it float off, much less work would be required of the boats, and the force employed upon other important parts of the work.

To remove the entire raft I estimate would cost about $150,000; but, as mentioned before, this is not particularly desired, on account of the injury likely to occur to the channel now formed. Certain portions, though, of the raft proper and tow-heads should be removed, so as to give a continuous channel of not less than 150 feet wide. To do this I estimate would cost about $50,000.

Below the raft, from Carolina Bluff for a distance of 30 miles down stream, the channel is only 90 feet wide. The banks in this stretch should be cleared of the willows and small growth, so as to allow the river to enlarge its channel. Jams are of frequent occurrence throughout this whole distance, and it is important that this much-needed work be done. To clear the banks I estimate would cost about $5,000.

Above the head of the raft the banks have been cleared of timber likely to cave into the river to within a short distance of Fulton, Ark. This work should be continued as high up as it is possible to go.

It is also found, below the present raft, that, on account of the cutting out of the bed and banks of the river, due to the removal of the raft above, many snags make their appearance, and are a source of danger to the safe navigation of the river. These snags are portions of the remains of the old raft, and are found all along the river formerly obstructed by the old raft-formation. They should also be removed. The steamer Aid, since her alteration, is well adapted to this work, and could be well employed during a portion of the season of high-water in removing them. Her running expenses would be about $1,800 per month, and for four months would be $7,200.

The original detailed estimate for the removal of the raft, as presented by Captain Howell, is as follows:

1. One stern-wheel saw-boat, fitted with 10 saws on sloping sides and bow, steam-crane, two steam-capstans, with equipage complete	$57,950 00
2. Flat-boat or scow, to receive water-logged raft from saw-boat	1,000 00
3. Stern-wheel tow-boat, with capstan and steam-crane, for unloading scow of saw-boat	10,000 00
4. Double-hull scow, with lifting and sawing apparatus, and small engine for working same	15,000 00
5. Stern-wheel tow-boat for same, with one steam-capstan and steam-crane for unloading water-logged snags	15,000 00
Total machinery and boats	98,950 00

ESTIMATE FOR WORK ONE YEAR.

No. 1, saw-boat, at $5,000 per month	$60,000 00
No. 3, with No. 2, at $1,000 per month	12,000 00

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Nos. 4 and 5	$20,000 00
Ax and saw party above raft	12,000 00
Ax and saw party below raft	3,000 00
Repairs of machinery, 10 per cent. on cost	9,895 00
Total work and repairs for one year	116,895 00

SUMMARY FOR ONE YEAR.

Boats and machinery	$98,950 00
Work and repairs	116,895 00
Contingencies, 20 per cent	43,169 00
	259,014 00

Subsequent expense of keeping river clear of raft and improving channel may be estimated, for first year after opening of channel, $50,000. Afterward the expense will decrease rapidly, but for several years the work of destroying raft material and guarding against jams must continue, at an annual expense of from $10,000 to $25,000.

Whole amount appropriated since commencement	$300,000 00
Amount expended since commencement	299,792 85

The estimates presented for a complete cleaning out of the raft and for other needful work in connection therewith will overrun the original estimate of Captain Howell, which was for one year. For the past two seasons comparatively little work has been done upon the raft proper. A portion of the appropriation has been expended in the purchase of a new steamer, to take the place of the "Sterling," worn out in service, and in repairing the "Aid" and other boats belonging to the original plant. The balance has been expended in removing such portions of the raft as was deemed advisable; in breaking up the various jams so as to keep the navigation uninterrupted and to prevent the re-formation of the raft, and also in cutting down the timber along the banks, which would, by caving into the river, tend to the same thing. This latter work was absolutely necessary, and belongs to the raft-work proper. At the present time I am advised that the river is again blocked by the running drift, but there being no funds on hand no work can be done.

To continue the work of removing such portions of the raft as may be deemed necessary, so as to secure a channel 150 feet wide; to cut down the leaning trees, to pull up all dangerous snags, and to prevent the re-formation of the raft by running drift, the additional estimates were inserted in this report.

Money statement.

Amount available July 1, 1875	$39,354 91
Amount expended during fiscal year ending June 30, 1876	39,147 76
Amount available July 1, 1876	207 15
Amount appropriated by act approved August 14, 1876	35,000 00
Amount (estimated) required for completion of existing project	115,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	75,000 00

K 4.

IMPROVEMENT OF CYPRESS BAYOU, AND CONSTRUCTION OF DAMS, AND DREDGING AT THE FOOT OF SODO LAKE, TEXAS.

Work was continued in July with the dredge-boat in finishing the cut that had been commenced the previous season. About 3,000 yards have been excavated and a number of stumps removed.

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The balance of the appropriation was so small that extended operations could not be carried on.

After finishing the cut the dredge was thoroughly repaired and laid up.

No work was done in Sodo Lake, there being no funds on hand for that purpose.

If an appropriation be made for the coming fiscal year, it is proposed to dredge at various points in the bayou, and also to remove stumps and other obstructions in the lake.

There has been no appropriation since that for the fiscal year ending June 30, 1874.

Total amount appropriated since commencement of work	$60,000 00
Total amount expended since commencement of work	59,977 90

Money statement.

Amount available July 1, 1875	$4,259 68
Amount expended during fiscal year ending June 30, 1876	4,237 58
Amount available July 1, 1876	22 10
Amount appropriated by act approved August 14, 1876	13,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	10,000 00

K 5.

WATER-GAUGES ON THE MISSISSIPPI RIVER AND ITS PRINCIPAL TRIBUTARIES.*

Observations were carried on at all the gauge-stations during the year. Such repairs as the gauges needed were made from time to time, so that at this date they are all in good condition, with the exception of that at Memphis. Work upon this one has been delayed in expectation that the city would do something toward repairing their levee, as it would be useless to put up a good, substantial gauge, like the one formerly here, with the levee in the condition it is at present. I have been husbanding the funds on hand for the purpose of putting this gauge in perfect order.

The gauges were established by Major Merrill, in accordance with a resolution passed by Congress in 1871, "with a view to obtain information required for the protection of the alluvial lands against overflow, and for the improvement of navigation." As the records of the different high and low waters, bench-marks, and other information were so scattered, I directed Mr. Joseph Burney, assistant engineer, assisted by Mr. Wm. M. Van Pelt, to collect all data bearing upon the subject, in order that the same might be embodied in one report. This was accordingly done, and the records of the gauges below will give all information collected and authorities for the same.

All the elevations given are referred to the gauges now used, with the exception of those at Lake Providence, Vicksburgh, and Red River Landing, at which stations no reliable connections could be made between the delta-survey gauges and the present ones.

The asterisk (*) means standard high or low water to which gauge is referred.

ALEXANDRIA GAUGE.

In December, 1871, a gauge was erected by Major Merrill. Location,

* The references in this report to "Physics and Hydraulics of the Mississippi River, Humphreys and Abbot," are to the first edition, Philadelphia, 1861.

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below the warehouse of Capt. John A. Williams. In 1872 inspected by Major Merrill. In September, 1874, repaired by Capt. R. W. Bringhurst, parish surveyor. In December, 1871, Capt. J. A. Williams was appointed observer, and still retains the position.

Bench-mark No. 1, (Merrill, 1871.) A metal star on the south end of the iron sill of the north door of the Ice House Hotel, and reads on gauge 35.853 feet.

Bench-mark No. 2, (Merrill, 1872.) An iron eightpenny nail driven into the mortar between the second and the third course of bricks (counting from the bottom, the first course being half sunk in the ground) in the brick building on the east corner of Jackson and Second streets; reads on gauge 34.202 feet.

Bench-mark No. 3, (Merrill, 1872.) The top projecting course of bricks in the foundation of the court-house, at the extreme east corner; reads on gauge 36.319 feet.

Oscillation, 39.06 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1849	.....	35.36	.....	.....	Major Merrill, (Chief of Engineers' Report 1873, page 521.)
1866	.....	*36.46	.....	.....	Do.
1871	.....	.....	Aug. —	0.0	Major Merrill, (Chief of Engineers' Report 1872, page 434.)
1872	April 29	33.30	Dec. 7	*—2.60	Major Merrill, (water-gauge records.)
1873	June 19	30.20	Oct. 1	—0.50	Do.
1874	May 8	34.90	Sept. 26	—2.00	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	April 27	23.90	Nov. 22	—2.20	Captain Benyaurd, (water-gauge records.)
1876	April 17	32.80	.....	.....	Do.

BATON ROUGE GAUGE.

In 1851 a gauge was established by Generals Humphreys and Abbot. Location, in front of Mr. Brown's mill, above the arsenal. From February 1, 1851, to February 28, 1853, observations were taken by Mr. J. W. Brown. In December, 1871, Major Merrill established the present gauge, the location being a short distance below the old saw-mill, about two squares below the State-house. In December, 1872, gauge rebuilt by Col. S. H. Lockett, C. E. In October, 1873, repaired by Mr. John V. Van Pelt, C. E. In December, 1875, repaired by Mr. Joseph Burney, C. E. From December, 1871, to July, 1873, Col. S. H. Lockett was observer; from July, 1873, to December, 1874, Mr. William M. Van Pelt; from December, 1874, Mr. S. L. Guyol, who still retains the position.

Bench-mark No. 1, (Merrill, 1871, "State-house B. M.,") is the top of lowest marble course of the State-house, taken on the west point at the middle of its northern half, which reads on the gauge 62.570 feet.

Bench-mark No. 2. Top of the inner cap (at southwest corner) that covers the pediment on which rests the 7th post on the west side from the northwest corner of the fence surrounding the State-house, which reads on the gauge 34.771 feet.

Bench-mark No. 3, (Van Pelt, 1873.) Mark on northeast corner of chimney of old mill, near the gauge, and reads 35.90 feet.

Bench-mark No. 4, (Van Pelt, 1873.) Top of stone at boundary-line between United States garrison and city property; reads on gauge 34.111 feet.

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To reduce delta-gauge records to present gauge, add 1.1 feet. Authority, Captain Benyaurd.

Oscillation, 35.95 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1828	April 1	34.7	.....	.....	Humphreys and Abbot, page 170.
1844	.....	33.9	.....	.....	Do.
1849	.....	34.9	.....	.....	Do.
1850	Mar. 15	34.5	.....	.....	Do.
1851	April 1	34.5	Nov. 24	3.5	Humphreys and Abbot, Appendix B, page 31.
1852	June 13	32.0	Oct. 31	3.9	Humphreys and Abbot, Appendix B, page 35.
1854	.....	.....	.....	*0.20	Major Merrill, (Chief of Engineers' Report, 1874, page 491.)
1858	.....	34.5	.....	.....	Humphreys and Abbot, page 170.
1859	May 6	35.0	.....	.....	Do.
1862	.....	36.10	.....	.....	Major Merrill, (Chief of Engineers' Report, 1874, page 491.)
1869	.....	34.49	.....	.....	Do.
1871	.....	34.50	.....	.....	Do.
1872	May 7	29.65	Dec. 22	1.15	Major Merrill, (water-gauge records.)
1873	June 17	29.85	Jan. 1	2.32	Do.
1874	April 16	*36.15	Nov. 21	2.30	High-water, Major Merrill; low-water, Captain Benyaurd; (water-gauge records.)
1875	May 13	29.75	Jan. 1	3.95	Captain Benyaurd, (water-gauge records.)
1876	May 8	38.40	.....	.....	Do.

CAIRO GAUGE.

In 1858 a gauge was established by Generals Humphreys and Abbot. From January 1 to August6, 1858, observations were taken by Mr. Arnold Syberg. From 1858 to 1868, observations were taken by the Cairo City Company, and copies of the records obtained by Major Merrill. In October, 1871, a gauge was erected by Major Merrill; location, by the side of the upper inclined railway of the freight-landing of the Illinois Central Railroad. In 1872, inspected by Major Merrill. In February, 1874, a new gauge was built by Mr. Charles Thrupp, C. E.; location, at the foot of 4th street. In October, 1871, Mr. M. S. Ensminger was appointed observer, and still retains the position.

Bench-mark No. 1, (Hely,) door-sill Saint Charles Hotel, northeast corner; reads on gauge 52.42 feet.

Bench-mark No. 2, (Hely,) door-sill Adler's store, between 4th and 6th, reads on gauge 52.79 feet.

Bench-mark No. 3, door-sill Donelly's store, between 18th and 20th, reads on gauge 52.94 feet. Grade of Ohio levee reads on gauge 51.16 feet; authority, Major Merrill, (Chief of Engineers' Report, 1874, page 489.) Grade of the Illinois Central Railroad on the levee reads on gauge 52.16 feet; authority, Major Merrill, (Chief of Engineers' Report, 1874, page 489.) Grade of Mississippi levee reads on gauge 53.16 feet; authority, Major Merrill, (Chief of Engineers' Report, 1874, page 489.)

To reduce delta-gauge records to present gauge, add 9.16 feet; authority, Major Abbot, (commission of engineers' report, page 108.) City datum-line reads on gauge 9.16 feet; authority, Major Merrill, (Chief of Engineers' Report, 1874, page 489.)

Oscillation, 51.97 feet.

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Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1858	June 21	49.56	.....	.....	Humphreys and Abbot, Appendix B, page 42.
1859	May 7	46.49	Nov. 10	5.33	Cairo City Co., (water-gauge records.)
1860	Jan. 23	37.24	Oct. 12	3.58	Do.
1861	April 24	43.16	.....	.....	Do.
1862	May 2	50.85	.....	.....	Do.
1864	Dec. 29	34.30	.....	.....	Do.
1865	Mar. 18	47.90	Dec. 4	6.51	Do.
1866	May 1	42.29	Aug. 18	9.76	Do.
1867	.....	*50.97	Dec. 14	2.70	Major Merrill, (Chief of Engineers' Report, 1872, page 429.)
1868	May 19	45.64	.....	.....	Cairo City Co., (water-gauge records.)
1871	.....	.....	Dec. 24	*—1.00	Major Merrill, (Chief of Engineers' Report, 1872, page 429.)
1872	April 19	39.90	Dec. 6	1.00	Major Merrill, (water-gauge records.)
1873	Feb. 26	41.55	Oct. 15	2.60	Do.
1874	April 26	47.40	Nov. 13	3.00	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	Aug. 8	45.12	Jan. 26	5.30	Captain Benyaurd, (water-gauge records.)
1876	April 6	46.38	.....	.....	Do.

CARROLLTON GAUGE.

From October 1, 1848, to June 30, 1855, daily observations were obtained by Professor Forshey, and those notes placed at the disposal of Generals Humphreys and Abbot for the delta survey. In 1857 a gauge was established by Generals Humphreys and Abbot, the location being a short distance above the depot. From November 4, 1857, to April 30, 1861, daily observations were taken by Mr. W. H. Williams. In January, 1872, Major Merrill erected a gauge, taking the same zero as that used in the delta survey, and erected the gauge near the old location. In January, 1873, repaired by Lieutenant Mahan, U. S. E. In March, 1874, inspected by Lieutenant Quinn, U. S. E. In August, 1874, repaired by Mr. W. B. Williams, C. E. In February, 1875, inspected, under the direction of Captain Howell, U. S. E., by Mr. H. C. Ripley, C. E. In April, 1875, rebuilt by Mr. T. W. Nicol, C. E. In December, 1875, inspected by Mr. Joseph Burney, C. E. In January, 1872, Mr. Wm. L. Duffy was appointed observer, and still retains the position. Mean Gulf level reads on gauge 0.14 feet; authority, Generals Humphreys and Abbot.

Bench-mark No. 1, ("Hampson," Merrill, 1871.) A large railroad-spike on the northwest corner of the machine-shop of the New Orleans and Carrollton Railroad; reads on gauge 7.92 feet.

Bench-mark No. 2, (Mahan, 1873.) On top of a large cypress mooring-post, a few feet on the down-stream side of the highest section of the gauge. It is the intersection of two diameters in a circle of about $\frac{3}{4}$-inch radius; circle and diameter made with silver-headed lining-tacks; reads on gauge 15.928 feet.

Bench-mark No. 3, (Ripley, 1875.) The top of a broken spike driven into the north face of the car-house of the New Orleans and Carrollton Railroad; said spike is 2 feet west of the west side of the door and on a level with the course of bricks upon which the door-sill rests; reads on gauge 11.14 feet.

Bench-mark No. 4, (Ripley, 1875.) The top of a ship-spike driven in the north side of the machine-shop of the New Orleans and Carrollton Railroad; 0.20 foot from the northwest corner; said spike is driven between the bricks, 37 courses from the top of the window-casing; reads on gauge 10.240 feet.

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Bench-mark No. 5, (Burney, 1875.) A mark thus: $\overset{\wedge}{\underset{75}{\text{U. S. E.}}}$, cut on west end of iron step of north door of the New Orleans and Carrollton Railroad depot, and reads on gauge 8.61 feet.

Oscillation, 17.30 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1849	Mar. 12	15.2	Oct. 6	2.10	Humphreys and Abbot, Appendix B, p. 27.
1850	Jan. 21	13.8	Nov. 18	−0.5	Humphreys and Abbot, Appendix B, p. 28.
1851	Mar. 27	15.4	Nov. 24	0.2	Humphreys and Abbot, Appendix B, p. 32.
1852	May 30	14.1	Feb. 4	0.6	Humphreys and Abbot, Appendix B, p. 36.
1853	May 30	15.0	Oct. 26	1.2	Humphreys and Abbot, Appendix B, p. 38.
1854	April 14	14.7	Dec. 30	0.0	Humphreys and Abbot, Appendix B, p. 39.
1855	April 7	9.5	.....	.....	Humphreys and Abbot, Appendix B, p. 40.
1857	.....	.....	Nov. 4	0.2	Humphreys and Abbot, Appendix B, p. 42.
1858	May 10	15.1	Nov. 5	0.4	Humphreys and Abbot, Appendix B, p. 47.
1859	May 4	15.6	Nov. 13	−0.4	Humphreys and Abbot, Appendix B, p. 51.
1860	Feb. 6	13.4	Oct. 18	−0.7	Humphreys and Abbot, Appendix B, p. 52.
1862	.....	15.36	.....	.....	Major Merrill, (Chief of Engineers' Report 1872, page 434.)
1871	.....	15.4	.....	.....	Do.
1872	May 6	12.30	Dec. 27	*−1.60	Major Merrill, (water-gauge records.)
1873	June 27	12.98	Nov. 20	0.08	Do.
1874	April 16	*15.70	Nov. 24	0.10	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	May 3	11.30	Nov. 13	0.10	Captain Benyaurd, (water-gauge records.)
1876	May 11	12.70	.....	.....	Do.

COLUMBUS GAUGE.

In 1857 a gauge was established by Generals Humphreys and Abbot at the foot of Dabney street. For bench-mark, see Humphreys and Abbot, Appendix B, page 23. From December 1, 1857, to August 30, 1859, observations taken by Mr. H. C. Fillebrown, C. E., and Mr. J. M. Moore. Highest observation, June 22, 1858, 40.9 feet; lowest observation, October 20, 1858, 3.1 feet.

DONALDSONVILLE GAUGE.

In 1851, a gauge was established by Generals Humphreys and Abbot. From January 30, 1851, to March 16, 1860, Mr. A. Gingry was observer. Location of gauge, on wharf-pile.

Bench-mark No. 1, (delta.) Top of pedestal of column of land-office, northwest corner; reads on gauge 28.18 feet.

Bench-mark No. 2, (delta.) On water-table of court-house, northeast corner; reads on gauge 28.82 feet.

Oscillation, 27.5 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1849	.....	30.1	.....	.....	Humphreys and Abbot, page 170.
1850	.....	28.8	.....	.....	Do.
1851	Mar. 27	30.3	Nov. 22	5.4	Humphreys and Abbot, Appendix B, p. 32.
1852	June 15	28.4	Nov. 1	6.3	Humphreys and Abbot, Appendix B, p. 35.
1853	May 28	27.9	Oct. 25	5.0	Humphreys and Abbot, Appendix B, p. 37.
1854	April 14	27.6	Dec. 29	3.0	Humphreys and Abbot, Appendix B, p. 38.
1855	April 7	18.8	Jan. 1	4.2	Humphreys and Abbot, Appendix B, p. 39.
1856	May 29	26.2	Oct. 15	3.0	Humphreys and Abbot, Appendix B, p. 40.
1857	Mar. 18	26.6	Nov. 4	3.2	Humphreys and Abbot, Appendix B, p. 41.
1858	May 10	30.0	Nov. 4	4.0	Humphreys and Abbot, Appendix B, p. 47.
1859	May 6	30.5	Sept. 5	3.5	Humphreys and Abbot, Appendix B, p. 51.

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FLORENCE GAUGE.

In November, 1871, a gauge was erected by Major Merrill; location, just below the north abutment of the railroad-bridge over the Tennessee River. In 1872, inspected by Major Merrill. In November, 1871, Mr. W. P. Stradford was appointed observer, and still retains the position.

Bench-mark No. 1, (Merrill, 1871.) Southeast corner of the top of the first small pier north of the bridge, and reads on gauge 30.193 feet.

Bench-mark No. 2, (Merrill, 1871.) Top of the northwest corner of the bridge-seat, on the abutment; reads on gauge 32.261 feet.

Oscillation, 31.84 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1867	.....	*31.08	.....	.....	Major Merrill, (Chief of Engineers' Report 1872, page 430.)
1871	.....	.....	.....	0.0	Do.
1872	Dec. 25	16.35	Oct. 24	*—0.76	Major Merrill, (water-gauge records.)
1873	Feb. 22	22.90	Oct. 21	—0.45	Do.
1874	April 17	26.00	Nov. 10	0.02	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	Mar. 8	29.38	Nov. 3	0.43	Captain Benyaurd, (water-gauge records.)
1876	Jan. 4	19.78	.....	.....	Do.

FORT LEAVENWORTH GAUGE.

From September 20, 1869, until the gauge was established by Major Merrill, observations were taken by the Kansas and Missouri Railroad Company, on a gauge located on the railroad-bridge. In November, 1871, a gauge was erected, under the direction of Major Merrill, by Lieutenant Ruffner, U. S. E.; location, below the pumping-engine house. In 1872 inspected by Major Merrill. In November, 1871, Mr. William N. Nutz was appointed observer, and still retains the position.

Bench-mark No. 1, (Merrill, 1872.) High-water mark of 1867 cut into rock near engine-house, and reads on gauge 22.06 feet. The zero of gauge reads 101.45 feet on railroad-bridge gauge; authority, Major Merrill, (Chief of Engineers' Report 1873, page 517.)

Oscillation, 22.06 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1867	.....	*22.06	.....	.....	Major Merrill, (Chief of Engineers' Report 1873, page 517.)
1869	.....	.....	Dec. 25	2.85	K. and M. R. R. Co., (water-gauge records.)
1870	April 13	16.75	Dec. 23	0.80	High-water, K. and M. R. R. Co.; low-water, Major Merrill, (water-gauge records.)
1871	June 11	13.95	Nov. 30	*0.00	Major Merrill, (water-gauge records.)
1872	July 14	16.39	Dec. 3	1.33	Do.
1873	July 6	19.07	Dec. 10	1.20	Do.
1874	June 17	15.90	Jan. 6	1.60	Do.
1875	April 30	17.70	Jan. 1	2.00	Captain Benyaurd, (water-gauge records.)
1876	June 14	16.25	.....	.....	Do.

HELENA GAUGE.

In 1858 a gauge was established by Generals Humphreys and Abbot, and from March 19 to July 20, 1858, observations taken. In November, 1871, a gauge was erected by Major Merrill near the coal-landing, being

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on the southern line of Mr. A. Fink's lot. In December, 1872, repaired by Lieutenant Mahan, U. S. E. In December, 1874, under the direction of Captain Benyaurd, a new gauge was erected by Mr. Joseph Burney, C. E., and the zero placed at low-water of 1872, making the zero 2.20 feet lower than the gauge erected by Major Merrill in 1871. In November, 1871, Mr. James B. Miles was appointed observer, and still retains the position.

Bench-mark No. 1, (Merrill, 1871.) The top of the first projecting course of bricks of the southern foundation-pier of Mr. Fink's house reads on gauge 43.09 feet.

Bench-mark No. 2, (Mahan, 1872.) In rear of the levee at the north end of the steps of Squire Williams's house; reads on gauge 46.138 feet.

Bench-mark No. 3, (Mahan, 1872.) In rear of levee at the southwest corner of the southeast column of the south porch of Mr. Quarell's house; reads on gauge 44.635 feet. To reduce records of delta-gauge to present gauge deduct 0.39 foot; authority, Captain Benyaurd.

Oscillation, 46.40 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1828	.....	43.11	.....	.....	Humphreys and Abbot, page 170.
1844	.....	42.21	.....	.....	Do.
1849	.....	42.81	.....	.....	Do.
1850	May 1	42.81	.....	.....	Do.
1851	.....	39.81	.....	.....	Do.
1858	July 2	44.61	.....	.....	Humphreys and Abbot, Appendix B, p. 44.
1859	Mar. —	43.61	.....	.....	Humphreys and Abbott, page 170.
1862	.....	*46.40	.....	.....	Major Merrill, (Chief of Engineers' Report 1872, page 432.)
1867	.....	45.82	.....	.....	Do.
1871	.....	.....	Dec. 29	1.15	Major Merrill, (water-gauge records.)
1872	April 26	39.03	Dec. 26	*0.00	Do.
1873	Mar. 6	40.00	Oct. 17	4.00	Do.
1874	May 11	45.80	Nov. 16	3.70	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	April 12	42.40	Jan. 28	6.50	Captain Benyaurd.
1876	April 18	44.85	.....	.....	Do.

JACKSONPORT GAUGE.

In November, 1871, a gauge was erected by Major Merrill; location, below Weisel's sawmill, between Main and Mill streets. In 1872, inspected by Major Merrill. In November, 1871, Mr. W. E. Bevans was appointed observer, and still retains the position.

Bench-mark No. 1, (Merrill, 1871.) Five copper tacks on the southern end of the sill of the southern door at the rear of Mr. Ganse's building; reads on gauge 31.692 feet.

Bench-mark No. 2, (Mahan, 1872.) Extreme northern end of door-sill on the east front of a brick building owned by Messrs. Adler & Goldman; reads on gauge 32.863 feet.

Bench-mark No. 3, (Mahan, 1872.) On the southern door-sill of the above front, and reads 32.812 feet.

Bench-mark No. 4, (Dukes, 1874.) Copper plug in southwest corner of court-house; reads on gauge 30.30 feet.

Bench-mark No. 5, (Dukes, 1874.) Copper plug in J. D. Goldman & Co.'s store; reads on gauge 33.32 feet.

Bench-mark No. 6, (Dukes, 1874.) Iron spike in locust-tree corner of Plumb street and alley; reads on gauge 26.94 feet.

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Bench-mark No. 7, (Dukes, 1874.) Iron spike in post corner of Jefferson street and alley; reads on gauge 31.26 feet.

Oscillation, 33.93 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1867	.....	*32.83	.....	.....	Major Merrill, (Chief of Engineers' Report 1879, page 431.)
1871	.....	.....	.....	0.00	Do.
1872	May 24	32.00	Dec. 24	*—1.10	Major Merrill, (water-gauge records.)
1873	April 13	30.00	Sept. 2	—0.70	Do.
1874	April 23	31.05	Nov. 3	—0.50	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	May 6	26.80	Oct. 29	—0.03	Captain Benyaurd, (water-gauge records.)
1876	Jan. 31	31.65	.....	.....	Do.

LAKE PROVIDENCE GAUGE.

In 1851 a gauge was established by Generals Humphreys and Abbot, the location being near the wharf-boat landing, and from February 11 to November 30, 1851, observations taken by Mr. W. J. Curry. In 1858 the gauge was again established by Generals Humphreys and Abbot, and from March 20 to August 21, 1858, daily observations taken. In December, 1871, a gauge was erected by Major Merrill opposite Mr. Le May's house, (since burned down.) In December, 1872, repaired by Lieutenant Mahan, U. S. E. In November, 1874, rebuilt by Mr. Joseph Burney, C. E. In February, 1875, rebuilt by Mr. T. W. Nicol, C. E. In December, 1875, rebuilt by Mr. Joseph Burney, C. E. In November, 1871, Mr. S. T. Le May was appointed observer, and still retains the position.

Bench-mark No. 1, (Mahan, 1872.) On the southwest corner of the slate pedestal of a monument erected to the memory of Reasin Bowie; reads on gauge 36.868 feet.

Bench-mark No. 2, (Burney, 1874.) On cottonwood-tree, 2,000 feet above present gauge location, 30 feet from and outside present levee, (3 nails represent bench-mark;) reads on gauge 36.637 feet.

Bench-mark No. 3, (Nicol, 1875.) Water-table southeast corner new court-house; reads on gauge 37.872 feet.

Bench-mark No. 4, (Nicol, 1875.) Upper ground-course of brick foundation-pillar southeast corner Le May House, now owned by Mr. John A. Guest; reads on gauge 32.988 feet.

No connection has been made between the gauge established by Generals Humphreys and Abbot and the present gauge.

Oscillation, 44.72 feet.

Generals Humphreys and Abbot's gauge.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1850	.....	45.0	.....	.....	Humphreys and Abbot, page 170.
1851	Mar. 10	45.6	.....	.....	Humphreys and Abbot, Appendix B, p. 29.
1858	Apr. 8	47.6	.....	.....	Humphreys and Abbot, Appendix B, p. 45.
1859	Apr. 25	48.4	.....	.....	Humphreys and Abbot, page 170.

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Present gauge.

1862	.....	*40.87	.....	.....	Major Merrill, (Chief of Engineers' Report 1872, page 432.)
1867	.....	39.99	.....	.....	Do.
1871	.....	.....	Dec. 31	—2.60	Major Merrill, (water-gauge records.)
1872	May 1	35.15	Dec. 29	*—3.85	Do.
1873	May 28	36.12	Nov. 4	0.91	Do.
1874	Mar. 21	37.37	Nov. 16	0.95	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	Apr. 19	37.29	Nov. 12	5.90	Captain Benyaurd, (water-gauge records.)
1876	Apr. 12	37.95	.....	.....	Do.

LITTLE ROCK GAUGE.

In October, 1871, Major Merrill established a gauge, and under his direction is was erected by Maj. S. McCormick, C. E. Location, foot of Commerce street. In December, 1872, inspected by Lieutenant Mahan, U. S. E. In March, 1872, Mr. Joseph Meyer was appointed observer, and still retains the position.

Bench-mark No. 1, (Mahan, 1872.) The extreme northern end of the sill of the north basement window of the warehouse to which gauge is attached; reads 31.203 feet.

Bench-mark No. 2, (Mahan, 1872.) Top of the eyebolt in a mooring-post on the levee 44 feet east from the northeast corner of the warehouse and almost on the prolongation of its northern face; reads on gauge 22.338 feet.

Bench-mark No. 3, (Mahan, 1872.) The side farthest from the river of the eyebolt in the mooring-post 30 feet east from bench-mark No. 2; reads on gauge 21.812 feet.

Oscillation, 31 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1857	.....	*31.00	.....	.....	Major Merrill, (Chief of Engineers' Report 1872, page 432.)
1864	.....	.....	.....	*0.00	Do.
1872	May 20	23.00	Dec. 4	0.80	Major Merrill, (water-gauge records.)
1873	Apr. 12	22.60	Sept. 23	0.40	Do.
1874	Apr. 25	23.00	Sept. 4	0.00	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	Aug. 5	21.80	Nov. 27	0.50	Captain Benyaurd, (water-gauge records.)
1876	Apr. 5	23.10	.....	.....	Do.

LOUISVILLE GAUGE, (UPPER.)

Observations in 1851, 1858, 1859, 1866, 1867, 1868, and 1869 were taken by Capt. E. Lockhart, superintendent of the Louisville and Portland Canal. In November, 1871, a gauge was established by Major Merrill, who states in his report, "the gauge was constructed at my request, under the direction of Maj. G. Weitzel, Engineers, by his assistant, Mr. Phillip J. Schoff."

The gauge is cut into the north abutment-wall of the upper guard-gate at the head of the Louisville and Portland Canal.

From November, 1871, to December, 1872, Capt. E. Lockhart was observer; from December, 1872, to April, 1874, Mr. Wm. Reynolds; from April, 1874, to February, 1875, Mr. J. B. Thompson; from February, 1875, Mr. H. N. Adams, who still retains the position.

The zero of gauge reads 35 feet on canal-levels; authority, Major Merrill, (Chief of Engineers' Report, 1872, page 429.)

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Bench-mark No. 1. Top of side-wall of guard-gate at head of canal on which gauge is cut; reads 20.588 feet.
Oscillation, 39.67 feet.

Year.	High-water.		Low water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1839	.....	*40.76	.....	.....	Major Merrill, (Chief of Engineers' Report 1873, p. 518.)
1851	Mar. 2	20.26	Oct. 5	1.51	Superintendent Louisville and Portland Canal.
1856	.....	.....	.....	*1.09	Major Merrill, (Chief of Engineers' Report 1873, p. 518.)
1858	June 17	19.09	Sept. 28	1.51	Superintendent Louisville and Portland Canal.
1859	Feb. 24	33.76	Sept. 20	2.01	Do.
1866	Jan. 1	18.59	Aug. 18	2.76	Do.
1867	Mar. 15	37.59	Oct. 22	1.84	Do.
1868	Mar. 31	22.26	July 30	3.01	Do.
1869	April 4	24.26	Aug. 25	2.76	Do.
1872	April 14	20.95	Oct. 7	2.00	Major Merrill, (water-gauge records.)
1873	Dec. 19	18.30	Oct. 1	2.30	Do.
1874	Feb. 26	22.35	Sept. 22	1.75	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	Aug. 7	30.30	Sept. 20	2.70	Captain Benyaurd, (water-gauge records.)
1876	Jan. 30	32.50	.....	.....	Do.

LOUISVILLE GAUGE, (LOWER.)

Observations in 1858, 1859, 1866, 1867, 1868, 1869 were taken by Capt. E. Lockhart, superintendent Louisville and Portland Canal. In 1871 a gauge was established by Major Merrill, who states in his report, "this gauge was constructed at my request under the direction of Maj. G. Weitzel, Engineers, by his assistant, Mr. Phillip Schoff." The location, near double lock at the foot of Louisville and Portland Canal. In 1872, inspected by Major Merrill. From November, 1871, to December, 1872, Capt. E. Lockhart was observer; from December, 1872, to April, 1874, Mr. Wm. Reynolds; from April, 1874, to February, 1875, Mr. J. B. Thompson; from February, 1875, Mr. H. N. Adams, who still retains the position.

Bench-mark No. 1 is the lower miter-sill lower lock new canal, which is 2 feet below zero.

The zero of gauge reads 8 feet on canal-levels; authority, Major Merrill, (Chief of Engineers' Report 1872, page 430.)

Oscillation, 66.50 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1839	.....	*67.50	.....	.....	Major Merrill, (Chief of Engineers' Report 1872, p. 430.)
1856	.....	.....	.....	*1.00	Do.
1858	June 17	42.33	Oct. 7	1.50	Superintendent Louisville and Portland Canal.
1859	Feb. 24	57.50	Sept. 20	2.50	Do.
1866	Sept. 27	41.75	Aug. 18	4.67	Do.
1867	Mar. 15	62.17	Oct. 22	3.00	Do.
1868	Jan. 11	48.75	Sept. 29	5.08	Do.
1869	April 4	49.00	Nov. 17	4.08	Do.
1872	April 14	45.37	Oct. 17	1.60	Major Merrill, (water-gauge records.)
1873	Dec. 19	42.80	Oct. 1	3.00	Do.
1874	Feb. 26	47.60	Nov. 15	2.80	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	Aug. 8	55.00	Sept. 20	4.10	Captain Benyaurd, (water-gauge records.)
1876	Jan. 30	58.00	.....	.....	Do.

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MEMPHIS GAUGE.

From September 5, 1848, to May 7, 1852, copy of records was obtained by Generals Humphreys and Abbot from water-gauge records, kept by the officers of the navy-yard. In 1857 a gauge was established by Generals Humphreys and Abbot, the location being in Wolf River near the boundary of the navy-yard. From December 20, 1857, to August 30, 1859, observations were taken by Mr. Michael Conway. In November, 1871, the erection of a gauge was commenced by Major Merrill and finished under the direction of the Memphis Harbor Committee, by Maj. J. H. Humphrey, city engineer, the location being about 120 feet south of Jefferson street. In 1872 inspected by Major Merrill. In November, 1871, Mr. W. L. Trask was appointed observer, and still retains the position.

Bench-mark No. 1, (delta.) Top of the water-table of rope-walk, navy-yard; reads on gauge 45.314 feet.

Bench-mark No. 2. Water-table at the northeast corner of Front and Poplar streets; reads on gauge 82.64 feet.

Bench-mark No. 3, (Nicol, 1876.) On door-sill corner of Front and Jefferson streets, and on Jefferson, marked thus: U. $\overline{S}$. E., and reads on gauge 90.336 feet.

Bench-mark No. 4, (Nicol, 1876.) On iron door-step entrance to upstairs, Frank's building, 280 Front street, marked thus: U. $\overline{S}$. E., and reads on gauge 89.012 feet.

To reduce delta-gauge records to present gauge deduct 1.14 feet; authority, Captain Benyaurd.

Zero of gauge reads on city levels 66 feet; authority, Major Merrill. (Chief of Engineers' Report 1872, page 430.)

Oscillation, 35.75 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1828	.....	32.86	.....	.....	Humphreys and Abbot, page 170.
1844	July —	33.16	.....	.....	Do.
1848	.....	.....	Nov. 3	1.36	Humphreys and Abbot, Appendix B, p. 26.
1849	Feb. 8	30.86	Sept. 23	3.46	Humphreys and Abbot, Appendix B, p. 27.
1850	May 18	33.56	Nov. 3	2.46	Humphreys and Abbot, Appendix B, p. 28.
1851	Mar. 11	33.16	Dec. 27	3.46	Humphreys and Abbot, Appendix B, p. 29.
1859	Apr. 21	32.96	Jan. 1	3.46	Humphreys and Abbot, Appendix B, p. 33.
1858	June 23	34.16	Oct. 24	2.86	Humphreys and Abbot, Appendix B, p. 43.
1859	May 12	34.06	.....	.....	Humphreys and Abbot, Appendix B, p. 48.
1867	.....	*34.80	.....	.....	Major Merrill, (Chief of Engineers' Report 1872, page 431.)
1871	.....	.....	Dec. 29	—0.92	Major Merrill, (water-gauge records.)
1872	Apr. 24	31.50	Dec. 25	*—0.95	Do.
1873	Mar. 3	32.50	Oct. 30	1.00	Do.
1874	May 2	34.00	Nov. 16	1.40	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	Aug. 15	33.05	Jan. 27	3.20	Captain Benyaurd, (water-gauge records.)
1876	Apr. 8	34.08	.....	.....	Do.

MOUTH OF WHITE RIVER GAUGE.

In November, 1871, a gauge was established by Major Merrill, the location being about 100 yards below the town, near the coal-fleet. In December, 1872, repaired by Lieutenant Mahan, U. S. E. In November, 1874, under the direction of Captain Benyaurd, a new gauge was erected by Mr. Joseph Burney, C. E., and the zero placed at the low-water of 1872, being 3.20 feet below the zero of gauge established by Major Merrill

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in 1871. In January, 1876, rebuilt by Mr. Joseph Burney, C. E. From November, 1871, to August, 1872, Mr. W. M. Ezell was observer; from August, 1872, to September, 1874, Capt. F. C. Kendall; from September, 1874, Dr. P. C. West, who still retains the position.

Bench-mark No. 1, (Burney, 1874.) Five copper tacks, thus ⁜, on M Brannon's gallery, reads on gauge 49.29 feet.

Bench-mark No. 2, (Burney, 1876.) A mark, thus $\overline{\times}$, made by tacks on southeast corner of "R. E. Lee" saloon on Main street; reads on gauge 49.208 feet.

Oscillation, 46.80 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1867	.....	*46.80	.....	.....	Major Merrill, (Chief of Engineers' Report 1872, page 432.)
1871	.....	.....	Dec. —	1.367	Do.
1872	Apr. 30	40.20	Dec. 28	*0.0	Major Merrill, (water-gauge records.)
1873	Apr. 25	42.90	Oct. 22	2.60	Do.
1874	Apr. 28	46.60	Nov. 16	2.70	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	Apr. 16	45.00	Jan. 28	6.80	Captain Benyaurd, (water-gauge records.)
1876	Apr. 10	46.70	.....	.....	Do.

NAPOLEON GAUGE.

In 1857 a gauge was established by Generals Humphreys and Abbot, and from December 26, 1857, to January 10, 1859, observations taken by Mr. A. A. Edington. Highest record, April 6, 1858, 45.4 feet; lowest record, November 4, 1858, 4.6 feet.

NASHVILLE GAUGE.

In August, 1873, a gauge was erected, under the direction of Major Merrill, by Mr. S. Thayer Abert, C. E.; location, at the wharf. In August, 1873, Mr. H. H. Harrison was appointed observer, and still retains the position.

Bench-mark No. 1, (Abert, 1873.) Top of second course of Messrs. Wood & Simpson's boiler-shop; reads on gauge 33.768 feet.

Bench-mark No. 2, (Abert, 1873.) Top of curb-stone at lamp-post, Harrison's corner; reads on gauge 48.811 feet.

Bench-mark No. 3, (Abert, 1873.) Top of curbstone at southwest corner of Broad and Front streets; reads 50.097.

Bench-mark No. 4, (Abert, 1873.) Top of sill-course, marked X, Harrison & Son's corner; reads on gauge 50.708 feet.

Zero of gauge reads 110.333 on city levels; authority, Major Merrill, (Chief of Engineers' Report 1874, page 489.)

Oscillation, 54.67 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
.....	.....	.....	.....	*0.00	Major Merrill, (Chief of Engineers' Report 1874, page 489.)
1847	.....	*54.67	.....	.....	Do.
1872	.....	.....	.....	1.00	Do.
1873	.....	.....	Oct. 14	0.50	Major Merrill, (water-gauge records.)
1874	Apr. 17	49.60	July 10	0.50	Do.
1875	Mar. 2	41.50	Sept. 18	1.20	Captain Benyaurd, (water-gauge records.)
1876	Jan. 29	34.40	.....	.....	Do.

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NATCHEZ GAUGE.

Observations of the river have been made here for a longer time than at any other station on the Mississippi River, extending back for a period of over 70 years. Quoting from Generals Humphreys and Abbot's Report, page 167:

In 1798 a regular record was began at Natchez by Governor Winthrop Sargent, and continued by him until 1819. From that date until 1841 observations at the same place were made by Mr. Samuel Davis. They were continued by Professor Forshey until 1848, when he removed to Carrollton and began a new series there.

Those records were compiled by Professor Forshey for delta survey. In 1851 a gauge was established by Generals Humphreys and Abbot, and from February 18 to November 30, 1851, observations taken by Mr. J. C. Brown. This gauge was again rebuilt by Generals Humphreys and Abbot in 1858, and from January 1, 1858, to January 31, 1859, observations taken by Lieut. H. S. Putnam and Mr. R. F. Learned. The location of the gauge was on Mr. Brown's breakwater. In December, 1871, a gauge was erected by Major Merrill, a short distance below the Natchez and Vidalia ferry-landing. In December, 1872, repaired by Lieutenant Mahan, U. S. E. In May, 1873, the location of the gauge was changed, and rebuilt in front of Messrs. Riddle & Coleman's coal-office by Mr. William Eustis, C. E. In June, 1874, inspected by Mr. C. Babbitt, C. E. In October, 1874, under the direction of Captain Benyaurd, new gauge was erected by Mr. Joseph Burney, C. E., and the zero placed at low-water of 1872, making the zero 1.20 feet below zero of gauge established by Major Merrill in 1871. In December, 1875, repaired by Mr. Joseph Burney, C. E. From December, 1871, to April, 1873, Mr. R. B. Monteith was observer; from April, 1873, to August, 1874, Mr. L. F. Carvey; from August, 1874, Mr. J. B. O'Brien, who still retains the position.

Bench-mark No. 1, (delta.) On hackberry-tree about 150 yards from the breakwater. The tree is in Mr. Brown's garden. Two or three spikes form the bench, which reads on gauge, 52.688 feet.

Bench-mark No. 2, (Merrill, 1871.) A copper tack driven into the southwest end of the door-sill of Mr. Cann's house, near the ferry; reads on gauge, 51.407 feet.

Bench-mark No. 3, (Babbitt, 1874.) On iron step, Fulton street, on Messrs. Ray & Grant's store; reads on gauge, 63.792 feet.

Bench-mark No. 4, (Babbitt, 1874.) A mark made by spikes on check-post on island, about 200 yards above Messrs. Riddle & Coleman's office; reads 49.456 feet.

Bench-mark No. 5, (Burney, 1875.) Iron spike driven into wall four courses above door-step on the river-front of ice-house belonging to Messrs. Riddle & Coleman; reads on gauge, 55.75 feet.

Bench-mark No. 6, (Burney, 1874.) A mark, thus, X, made by tacks on top of check-post on wharf; reads on gauge, 46.19 feet.

To reduce records of delta gauge to present gauge, deduct 4.70 feet authority, Captain Benyaurd.

Oscillation, 49 feet.

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Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1808	Apr. 20	46.8			Humphreys and Abbot, Plate 9, Fig. 2.
1809	May 4	47.0			Do.
1811	June 4	47.1			Do.
1812	June 15	45.0			Do.
1813	June 8	48.3			Do.
1814	June 17	46.3			Do.
1815	June 2	48.6			Do.
1816	May 2	46.0			Do.
1817	May 1	46.1			Do.
1818	Apr. 20	45.1			Do.
1819	May 27	46.9			Do.
1820	Apr. 5	44.9			Do.
1821	Mar. 30	46.6			Do.
1822	June 1	46.3			Do.
1823	May 23	48.4			Do.
1824	May 6	47.9			Do.
1825	May 2	46.9			Do.
1826	Mar. 12	46.3			Do.
1827	Apr. 26	44.3			Do.
1828	Mar. 26	48.4			Do.
1829	May 7	41.4			Do.
1830	May 19	46.4			Do.
1831	May 7	46.2			Do.
1832	Mar. 17	46.1			Do.
1833	Mar. 12	43.6			Do.
1834	Apr. 6	42.6			Do.
1835	June 3	44.6			Do.
1836	May 31	47.3			Do.
1837	Apr. 20	45.3			Do.
1838	Apr. 16	44.7			Do.
1839	Apr. 8	87.5			Do.
1840	June 10	47.1			Do.
1841	May 30	45.8			Do.
1842	Apr. 8	46.2			Do.
1843	June 28	46.8			Do.
1844	July 16	47.8			Do.
1845	Apr. 10	45.1			Do.
1846	June 2	45.3			Do.
1847	Apr. 22	47.8			Do.
1848	June 28	48.0			Do.
1849		47.5			Do.
1850		45.3			Do.
1851	Apr. 3	47.1			Do.
1852	June 5	45.1			Do.
1853	June 1	44.3			Do.
1854	Apr. 3	43.3			Do.
1855	Apr. 1	36.3			Do.
1856	Mar. 22	42.8			Do.
1857	Mar. 16	43.0			Do.
1858	June 28	47.8			Do.
1859	May 2	*49.0			Do.
1862		45.16			Major Merrill, (Chief of Engineers' Report 1873, page 521.)
1867		47.9			Do.
1868		43.9			Do.
1869		46.1			Do.
1870		44.3			Do.
1871		43.8		1.20	High-water, Captain Benyaurd; low-water, Major Merrill, (Chief of Engineers' Report 1872, page 433.)
1872	May 5	39.85	Dec. 15	*0.00	Major Merrill, (water-gauge records.)
1873	May 30	40.15	Jan. 1	0.95	Do.
1874	Apr. 20	45.60	Nov. 17	2.70	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge record.)
1875	Apr. 26	41.85	Jan. 1	7.00	Captain Benyaurd, (water-gauge record.)
1876	May 15	43.85			Do.

NEW CARTHAGE GAUGE.

In 1851 a gauge was established by Generals Humphreys and Abbot. From February 9, 1851, to March 30, 1853, observations taken by Mr. A. R. Adkins. The highest observed elevation, March 31, 1851, 44 feet; the lowest, November 1, 1852, 4.4 feet.

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RED RIVER LANDING GAUGE.

In 1851 a gauge was established by Generals Humphreys and Abbot, and from February 18, 1851, to June 18, 1852, observations were taken by Mr. Miguel Torras. In 1858 the gauge was re-established by Generals Humphreys and Abbot, and from January 25, 1858, to January 31, 1859, observations taken by Mr. Miguel Torras; the location of the gauge being at the wharf-boat landing, below Mr. Torras's house. In December, 1871, a gauge was erected by Major Merrill; location, near the wharf-boat. In December, 1872, inspected by Lieutenant Mahan, U. S. E. In April, 1873, repaired by Mr. William Eustis, C. E. In September, 1873, rebuilt by Mr. Charles Babbitt, C. E. In October, 1874, under the direction of Captain Benyaurd, a new gauge was erected by Mr. Joseph Burney, C. E., and the zero of gauge placed at low-water of 1872, making the zero 3 feet below the gauge erected by Major Merrill in 1871. In December, 1875, rebuilt by Mr. Joseph Burney, C. E. From December, 1871, to July, 1875, Maj. A. D. Smith was observer; from July, 1875, Capt. J. L. Kingsbury, who still retains the position.

Bench-mark No. 1, (Mahan, 1872.) One of 4 square oak posts at the angle of a square of which the diagonals are 100 feet. These posts are marked A, B, C, D, by means of silver-headed lining-tacks driven into the heads of the posts, the exact point being indicated by a tack driven into the top of each post, at the southwest corner. Post marked A reads on gauge 44.035 feet.

Bench-mark No. 2, (Mahan, 1872.) Post marked B reads 43.297 feet.

Bench-mark No. 3, (Mahan, 1872.) Post marked C reads 43.133 feet.

Bench-mark No. 4, (Mahan, 1872.) Post marked D reads 43.489 feet.

Bench-mark No. 5, (Burney, 1875.) A mark, thus $\overline{\Lambda}$, made by tacks, on cottonwood-tree near wharf-boat, on which upper section of gauge is fastened, and reads on gauge 45. feet.

No connection has been made between the gauge established by Generals Humphreys and Abbot and the present gauge.

Oscillation, 47 feet.

Generals Humphreys and Abbot's gauge.

Year.	High water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1850	.....	47.5	.....	.....	Humphreys and Abbot, page 170.
1851	April 1	46.4	Nov. 24	2.2	Humphreys and Abbot, Appendix B, p. 31.
1852	June 8	43.9	.....	.....	Humphreys and Abbot, Appendix B, p. 34.
1858	July 13	45.7	Nov. 3	6.1	Humphreys and Abbot, Appendix B, p. 46.

Present gauge.

1867	.....	46.33	.....	.....	Major Merrill. (Chief of Engineers' Report 1872, page 434.)
1871	.....	44.5	Dec. 31	2.05	High-water, Major Merrill, (Chief of Engineers' Report, 1872, page 434; low-water, Major Merrill, (water-gauge records.)
1872	May 6	39.42	Dec. 15	*0.00	Major Merrill, (water-gauge records.)
1873	June 12	39.02	Jan. 1	1.50	Do.
1874	April 16	*47.00	Nov. 22	1.90	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	May 3	40.45	Jan. 1	6.00	Captain Benyaurd, (water-gauge records.)
1876	May 15	45.41	.....	.....	Do.

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ROCK ISLAND GAUGE.

From January 1, 1860, to December 31, 1870, observations were taken by the Rock Island and Pacific Railroad Company on a gauge located on the pivot-pier of the old railroad-bridge. From January 1, 1871, to September 30, 1871, observations were taken under the direction of Colonel Macomb, U. S. E. In October, 1871, Major Merrill established the present gauge, and states in his report:

This gauge is cut into the stone pivot-pier of the United States railroad and highway bridge, and for its construction I am indebted to Colonel Macomb and Captain Stickney, of the Engineers.

In 1872 inspected by Major Merrill. From October, 1871, to May, 1873, Mr. A. M. Scott, C. E., was the observer, and from May, 1873, Mr. George F. Evans, who still retains the position. The zero of gauge on the United States railroad-bridge was placed at the same level as the gauge on old railroad-bridge; authority, Major Merrill, (Chief of Engineers' Report 1872, page 429.)

Bench-mark No. 1. The coping of pivot-pier of bridge, which reads, 21 feet on gauge and bridge levels.

Oscillation, 16.71 feet.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1860	Dec. 25	13.13	Nov. 29	0.88	Rock Island and Pacific gauge-records.
1861	April 27	14.79	Dec. 5	0.88	Do.
1862	May 4	15.79	Dec. 8	0.29	Do.
1863	May 1	8.63	Jan. 9	0.63	Do.
1864	Feb. 29	8.46	Sept. 2	*0.00	Do.
1865	Mar. 4	11.08	Dec. 11	1.04	Do.
1866	May 4	15.67	Oct. 20	1.71	Do.
1867	June 28	14.33	Dec. 6	0.92	Do.
1868	Mar. 10	†17.00	Aug. 26	1.58	Do.
1869	Oct. 9	12.92	Dec. 8	2.33	Do.
1870	April 24	*16.71	Dec. 21	1.92	Do.
1871	May 15	12.85	Nov. 28	0.60	Major Merrill, (water-gauge records.)
1872	May 28	9.30	Nov. 24	0.65	Do.
1873	May 6	12.15	Nov. 24	0.80	Do.
1874	Mar. 10	14.90	Dec. 2	0.50	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	April 30	12.95	Nov. 27	0.10	Captain Benyaurd, (water-gauge records.)
1876	May 10	13.10	.....	.....	Do.

† This rise was caused by an ice-gorge, and consequently not taken as a standard of reference.

SAINT LOUIS GAUGE.

Records were kept by the city of Saint Louis, at irregular intervals, extending back to the year 1844. From 1860 to 1871, with few exceptions, observations were taken daily, and copies of these records were obtained by Major Merrill. No gauge was erected by the city, the observations being taken, by an engineer, with a level. From October 16, 1871, to July 1, 1873, under the direction of Major Merrill, observations were taken from a gauge erected on the elevator. In December, 1873, a gauge was erected, under the direction of Major Merrill, by Mr. Julius Rapp, assistant city engineer, the location being opposite No. 4 South Main street. In October, 1871, Mr. Jacob Leopold was appointed observer, and still retains the position. The city directrix reads on gauge 33.81 feet; authority, Major Merrill, (Chief of Engineers' Report 1874, page 488.)

Oscillation, 41.39 feet.

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Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1826	.....	33.81	.....	.....	City of Saint Louis gauge-records.
1844	June 27	*41.39	.....	.....	Do.
1851	June 19	36.61	.....	.....	Do.
1858	June 15	37.21	.....	.....	Do.
1860	.....	.....	Dec. 27	0.60	Do.
1861	May 15	25.47	Jan. 1	1.33	Do.
1862	April 26	31.45	Jan. 8	3.48	Do.
1863	Mar. 4	18.02	Dec. 21	*0.00	Do.
1864	May 14	20.33	Jan. 2	1.22	Do.
1865	July 28	26.81	Feb. 2	1.19	Do.
1866	April 25	26.77	Dec. 21	5.79	Do.
1867	May 1	28.21	Dec. 19	1.27	Do.
1868	May 14	24.19	Jan. 14	0.85	Do.
1869	July 24	29.31	Jan. 2	5.61	Do.
1870	April 16	26.21	Dec. 24	5.26	Do.
1871	.....	.....	Dec. 21	2.84	Major Merrill, (water-gauge records.)
1872	June 19	23.00	Dec. 4	2.50	Do.
1873	April 11	25.45	Nov. 30	3.87	Do.
1874	June 20	18.40	Dec. 31	2.80	High-water, Captain Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	Aug. 3	29.80	Jan. 3	2.30	Captain Benyaurd, (water-gauge records.)
1876	May 10	32.06	.....	.....	Do.

VICKSBURG GAUGE.

In 1858 a gauge was established by Generals Humphreys and Abbot at the foot of Crawford street, and from February 17, 1858, to September 12, 1859, observations were taken by Lieut. H. S. Putnam and Mr. H. A. Pattison, C. E., Mr. J. J. Conway and Mr. A. Y. Nolley. In December, 1871, a gauge was erected by Major Merrill on the elevator building. In December, 1872, inspected by Lieutenant Mahan, U. S. E. In December, 1874, rebuilt by Mr. Joseph Burney, C. E., and in November, 1875, inspected by Mr. T. W. Nicol, C. E. From December, 1871, to June, 1872, the observer was Mr. H. G. Fairchild. From June, 1872, to October, 1874, Mr D. P. Fithian, and from October, 1874, Mr. George W. Bausman, jr., who still retains the position.

Bench-mark No. 1, (Merrill, 1871.) An iron spike driven into wall northwest corner of the Prentiss House, (being the height of high-water of 1862;) reads 51.10 feet.

Bench-mark No. 2, (Burney, 1874.) On lower projecting course of buttress east of main door of Catholic church; reads on gauge 183.61 feet.

Bench-mark No. 3, (Burney, 1874.) The projecting course of bricks near iron pillar on southeast corner of brick building corner of South and Washington streets, belonging to Mr. John A. Klein; reads on gauge 158.87 feet.

No connection has been made between the gauge established by Generals Humphreys and Abbot and the present gauge.

Oscillation, 52.40 feet.

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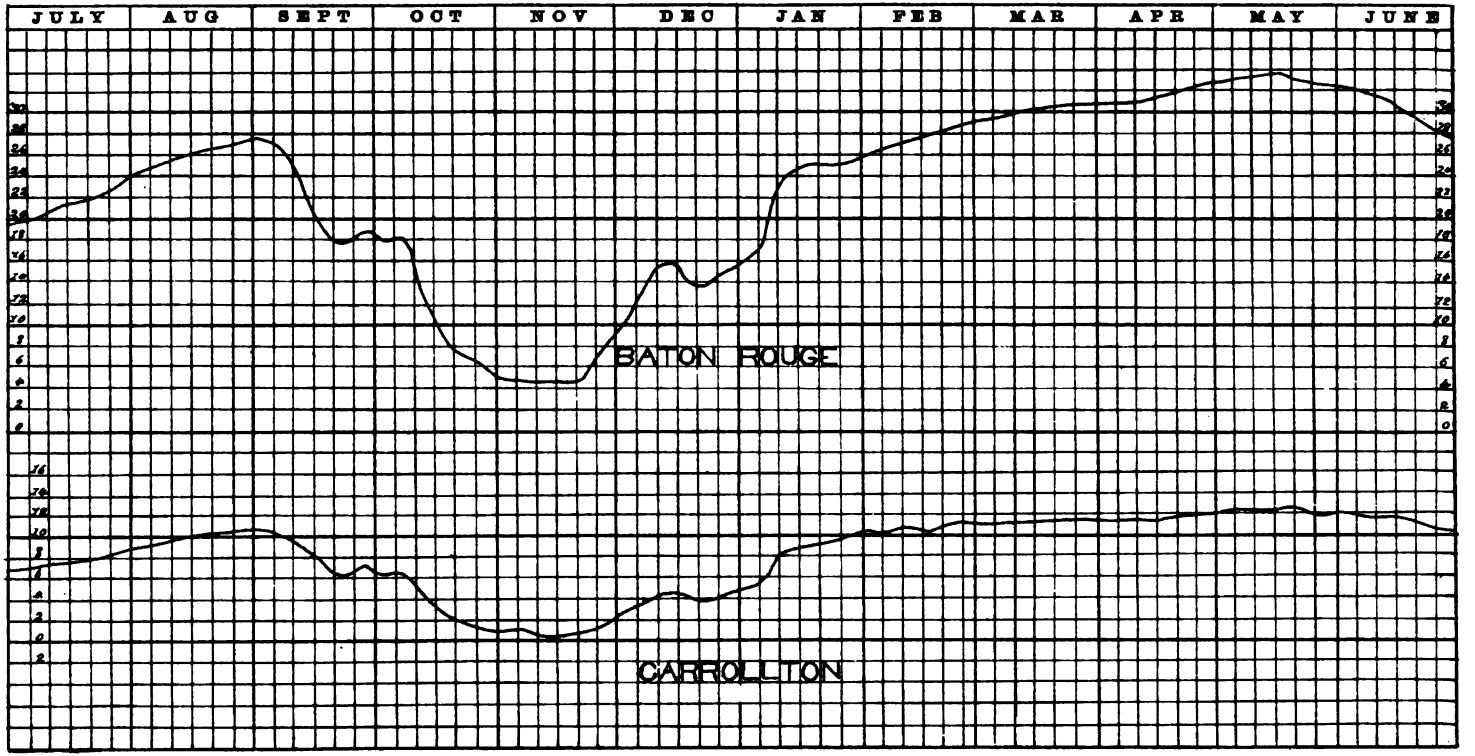
OSCILLATIONS MISSISSIPPI RIVER, '75, '76.



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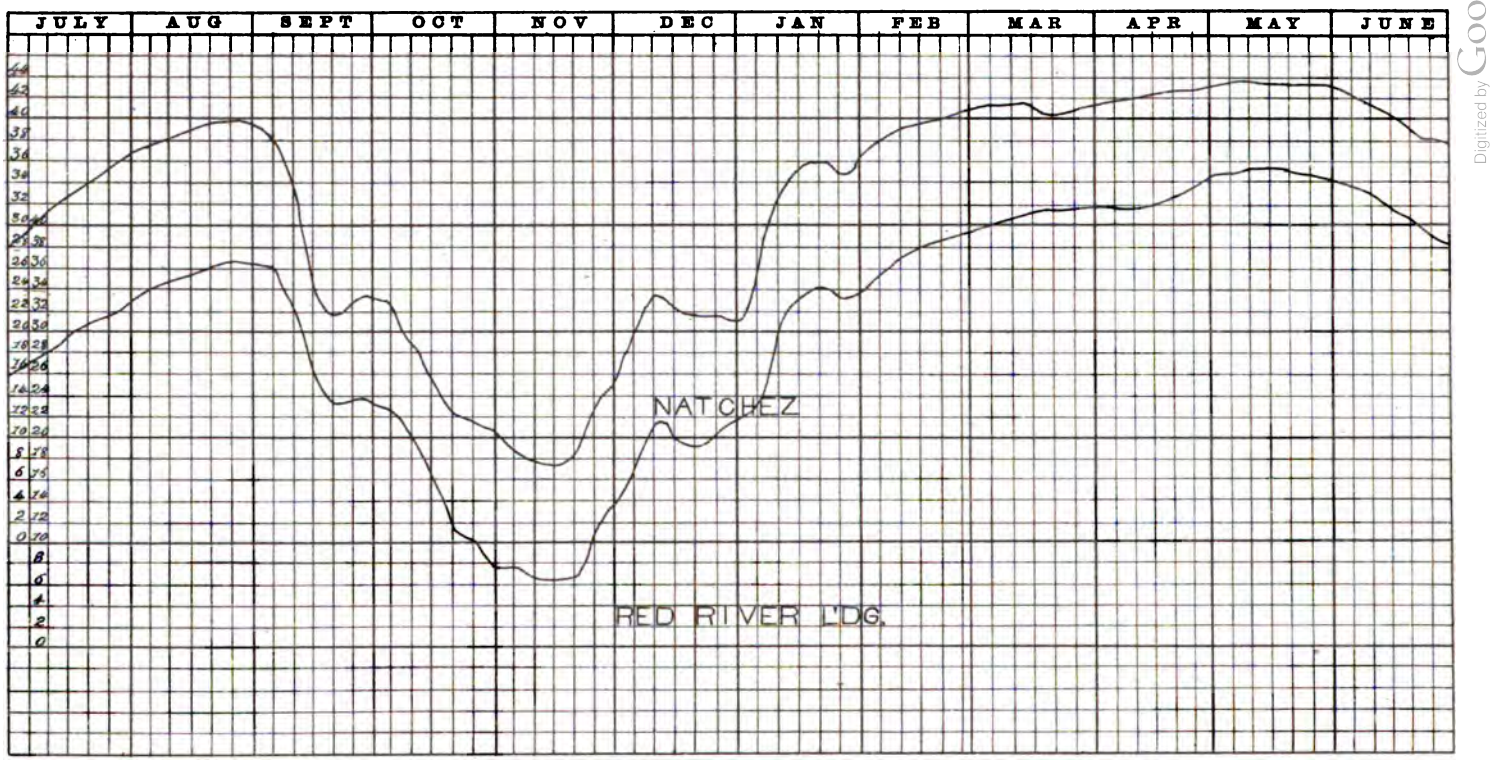
OSCILLATIONS MISSISSIPPI RIVER, '75, '76.



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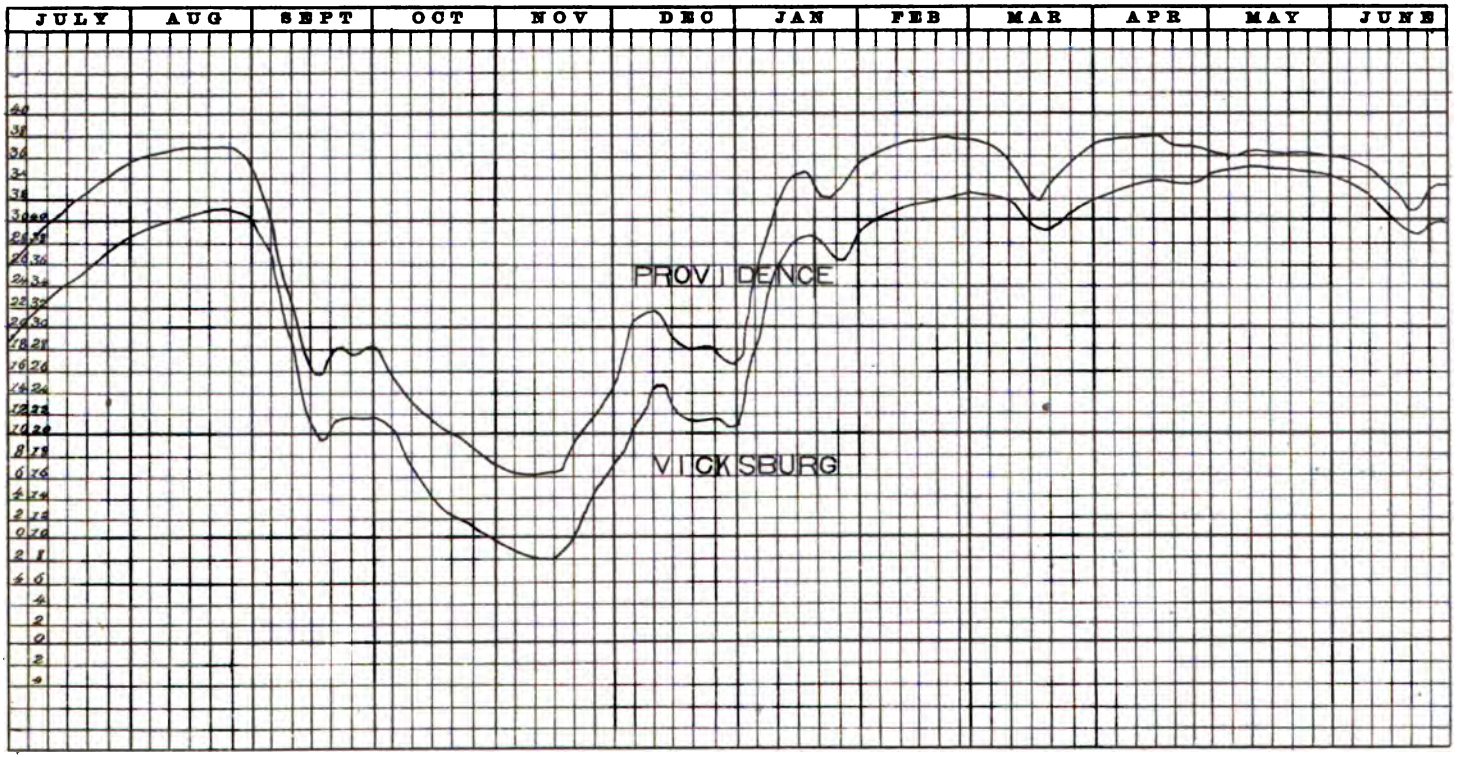
OSCILLATIONS MISSISSIPPI RIVER, '75, '76.



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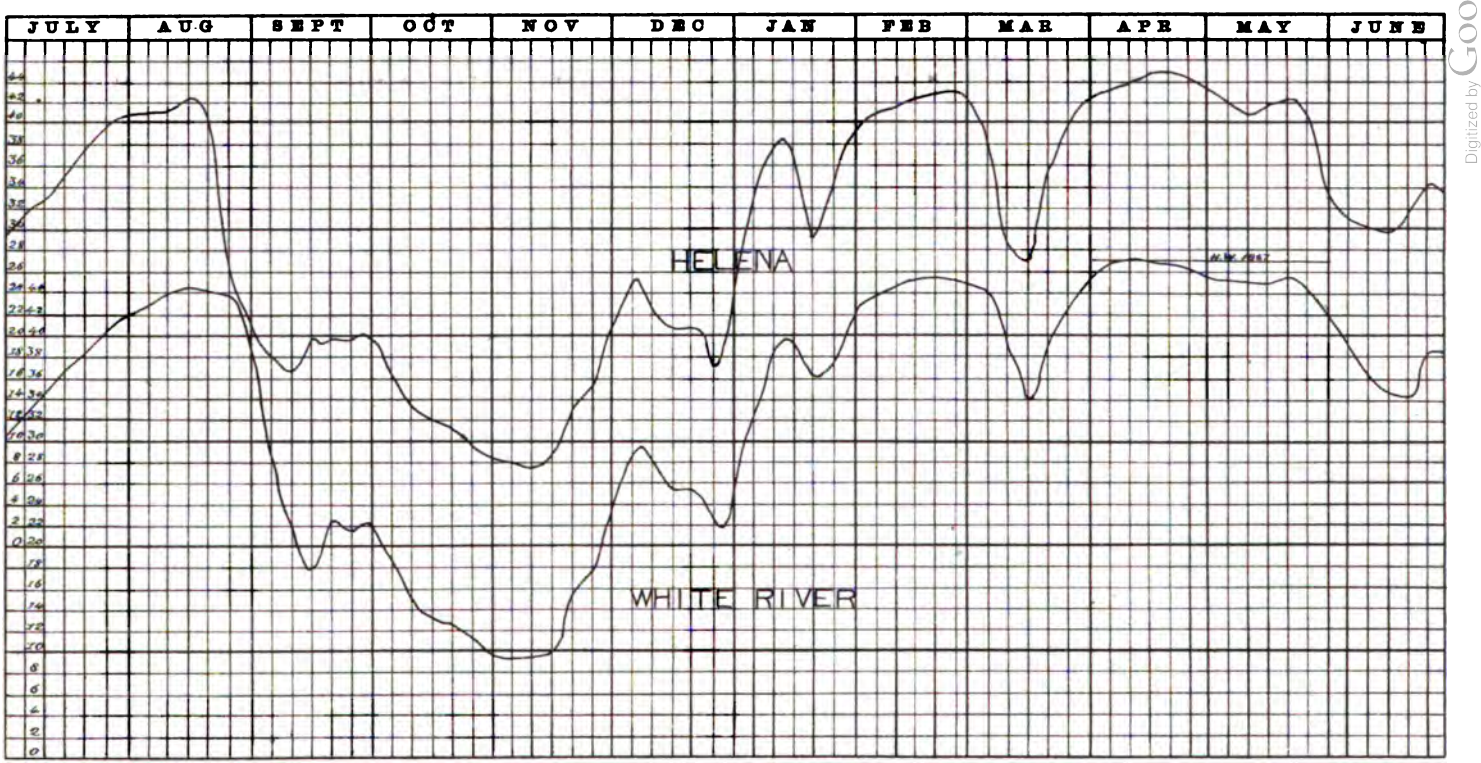

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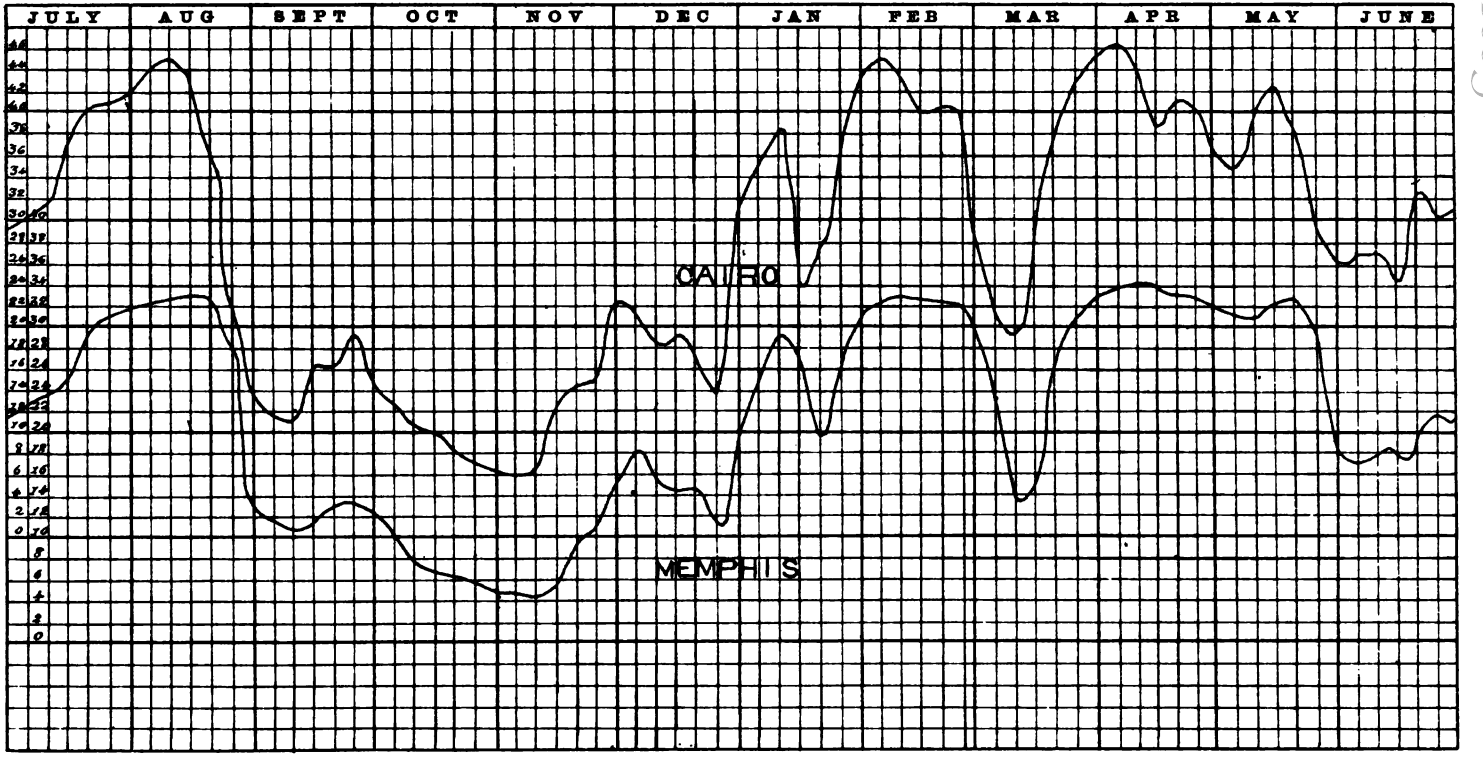
OSCILLATIONS MISSISSIPPI RIVER, '75, 76.



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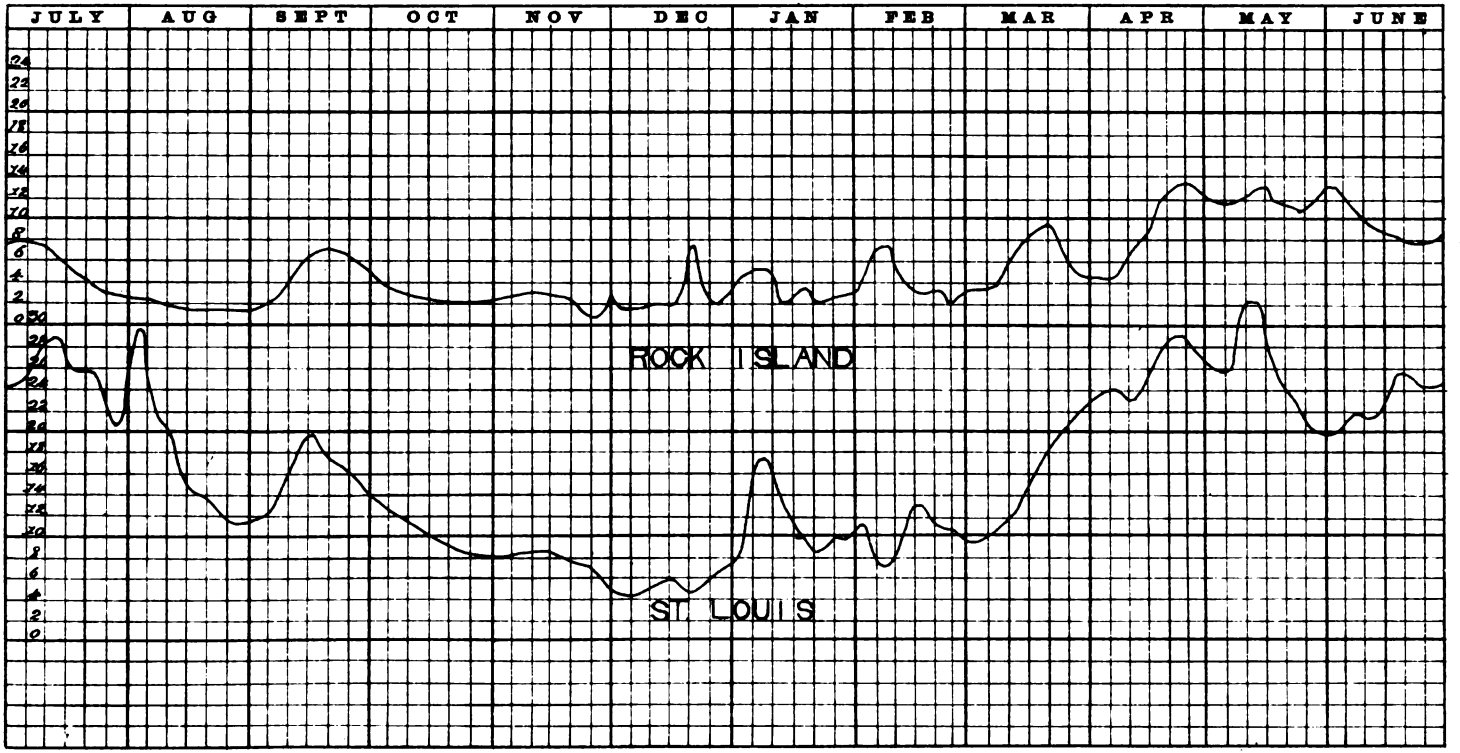

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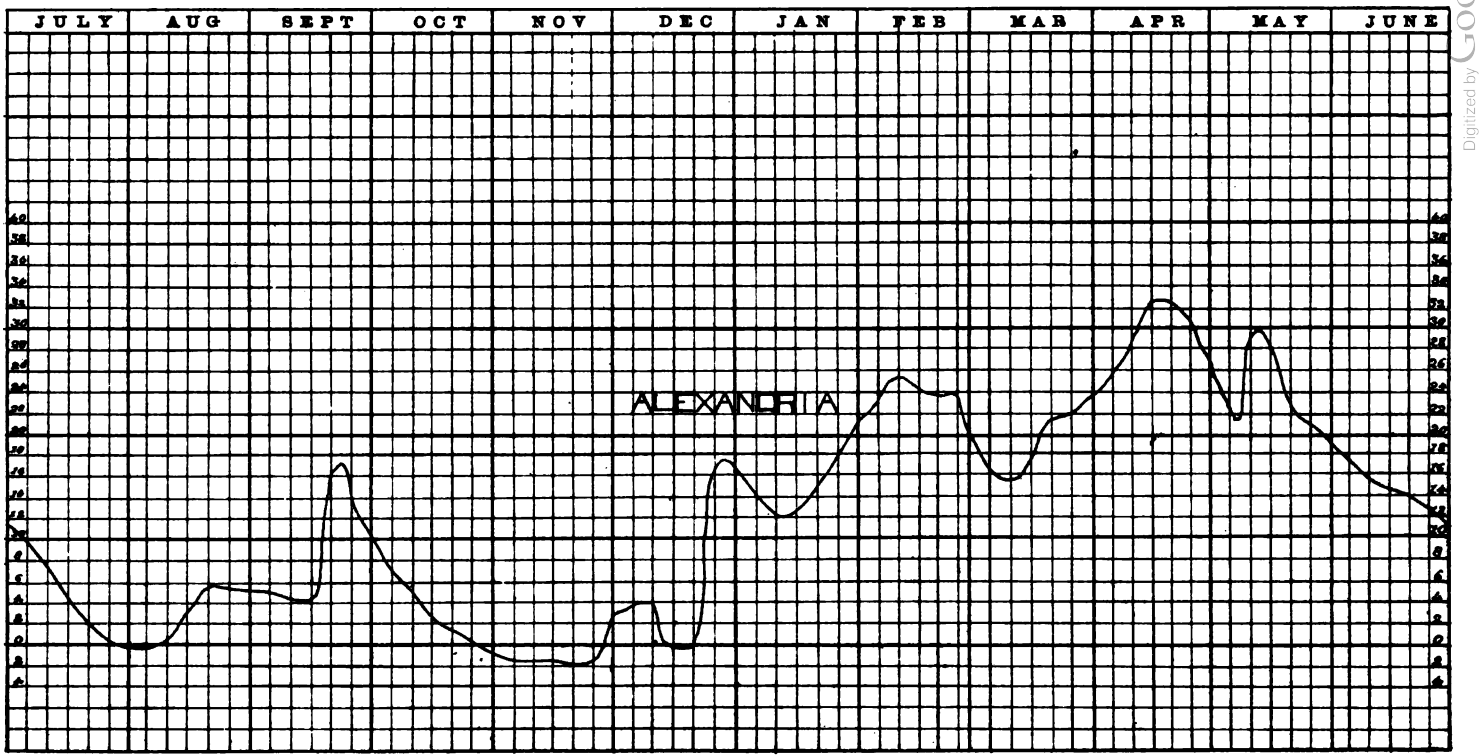
OSCILLATIONS RED RIVER, '75'76



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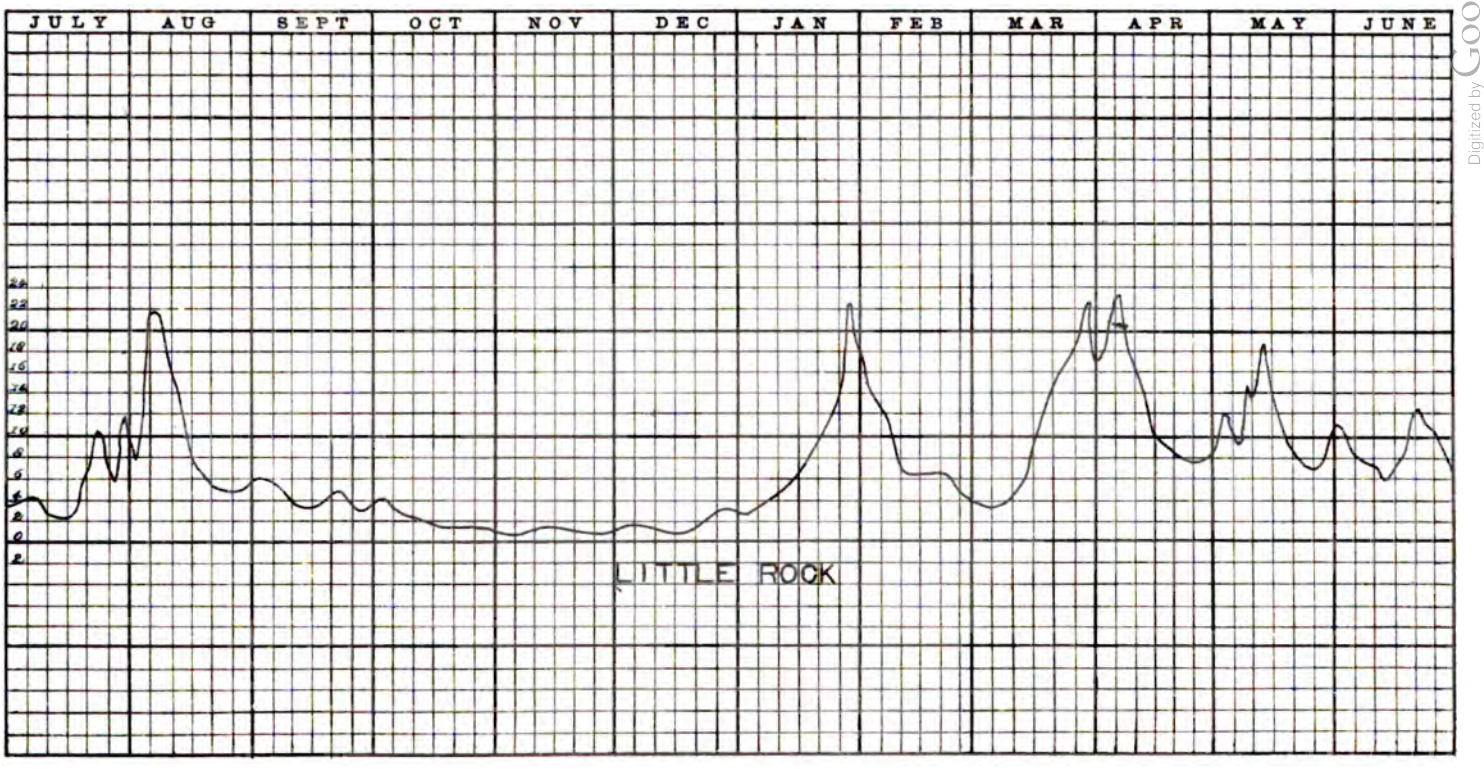
OSCILLATIONS ARKANSAS RIVER, '75 '76



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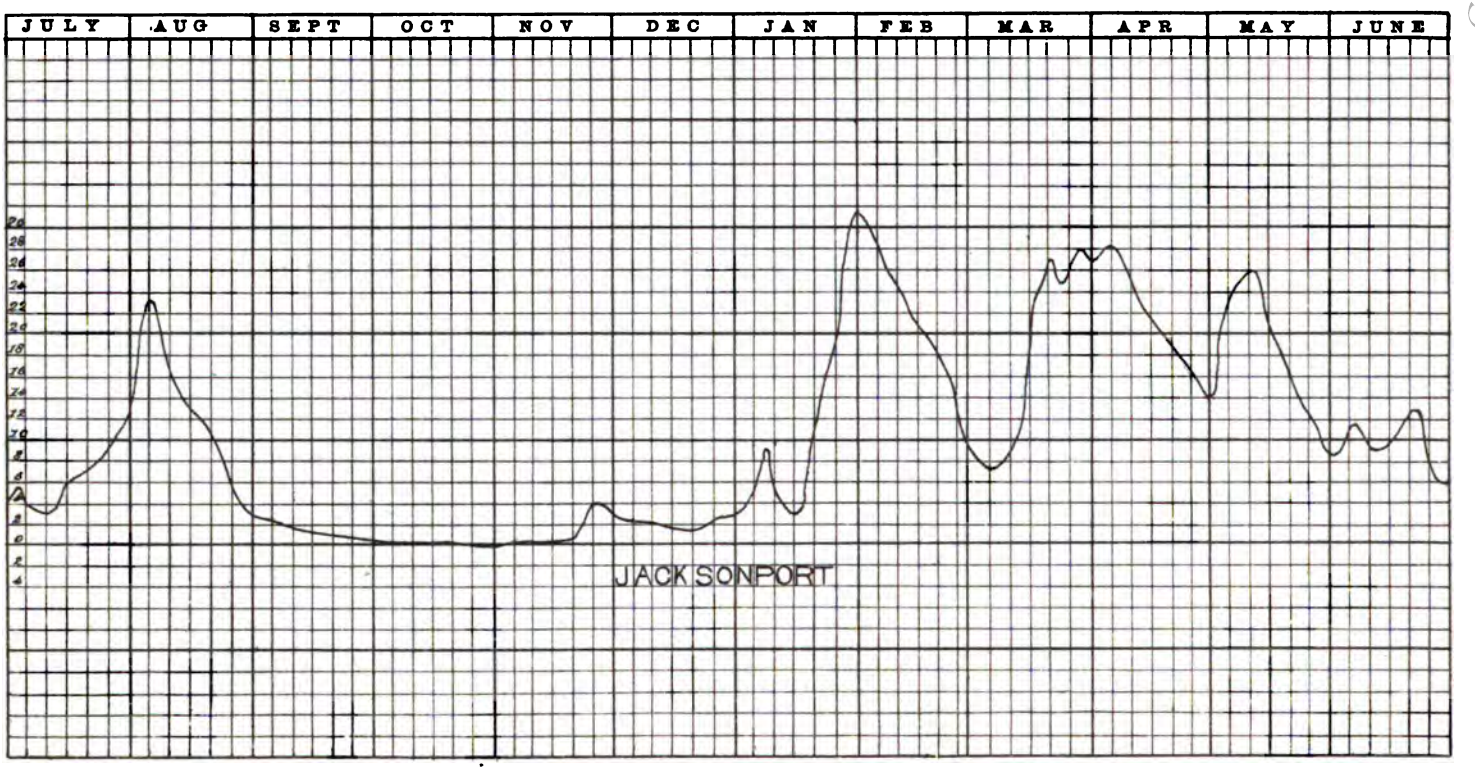
OSCILLATIONS WHITE RIVER, '75 '76



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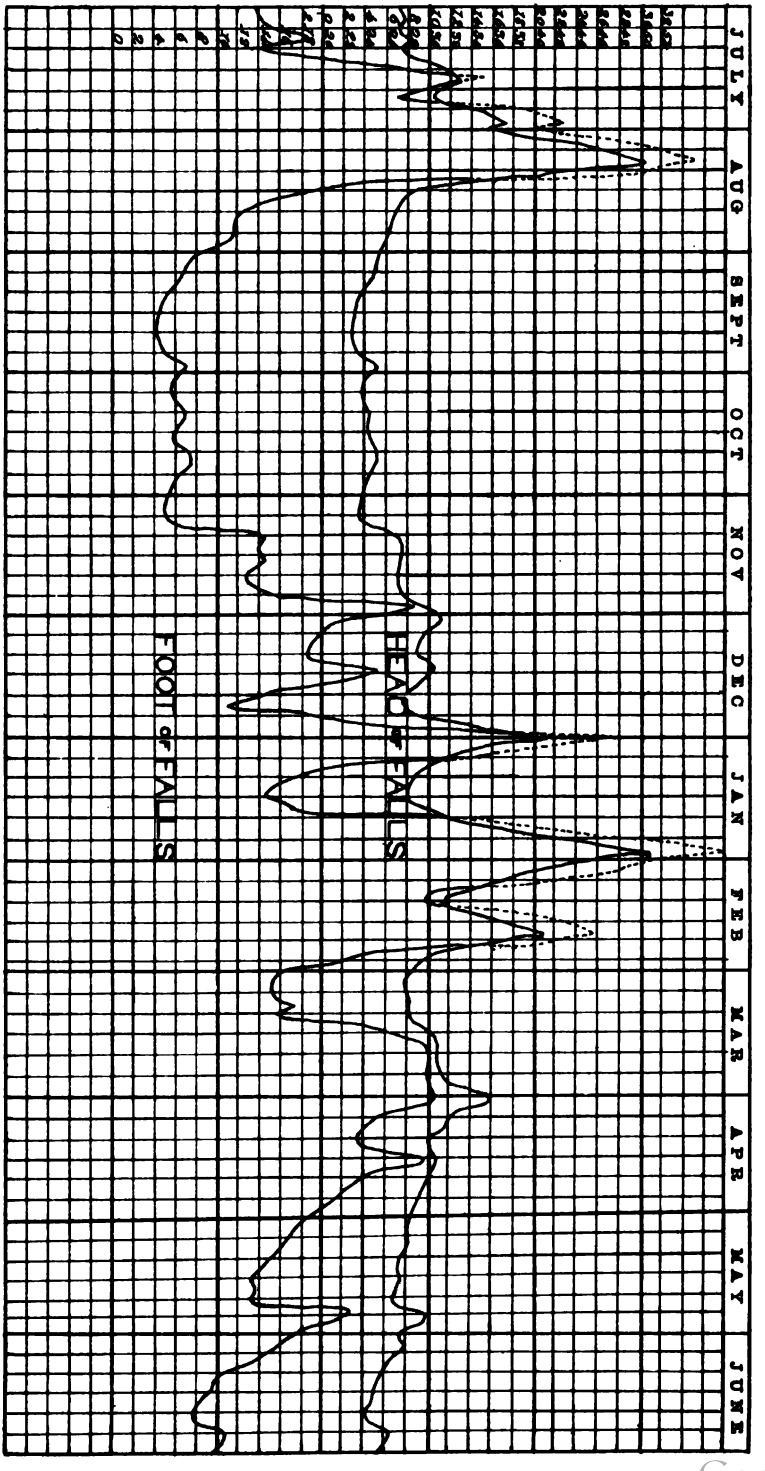

OSCILLATIONS OHIO RIVER,

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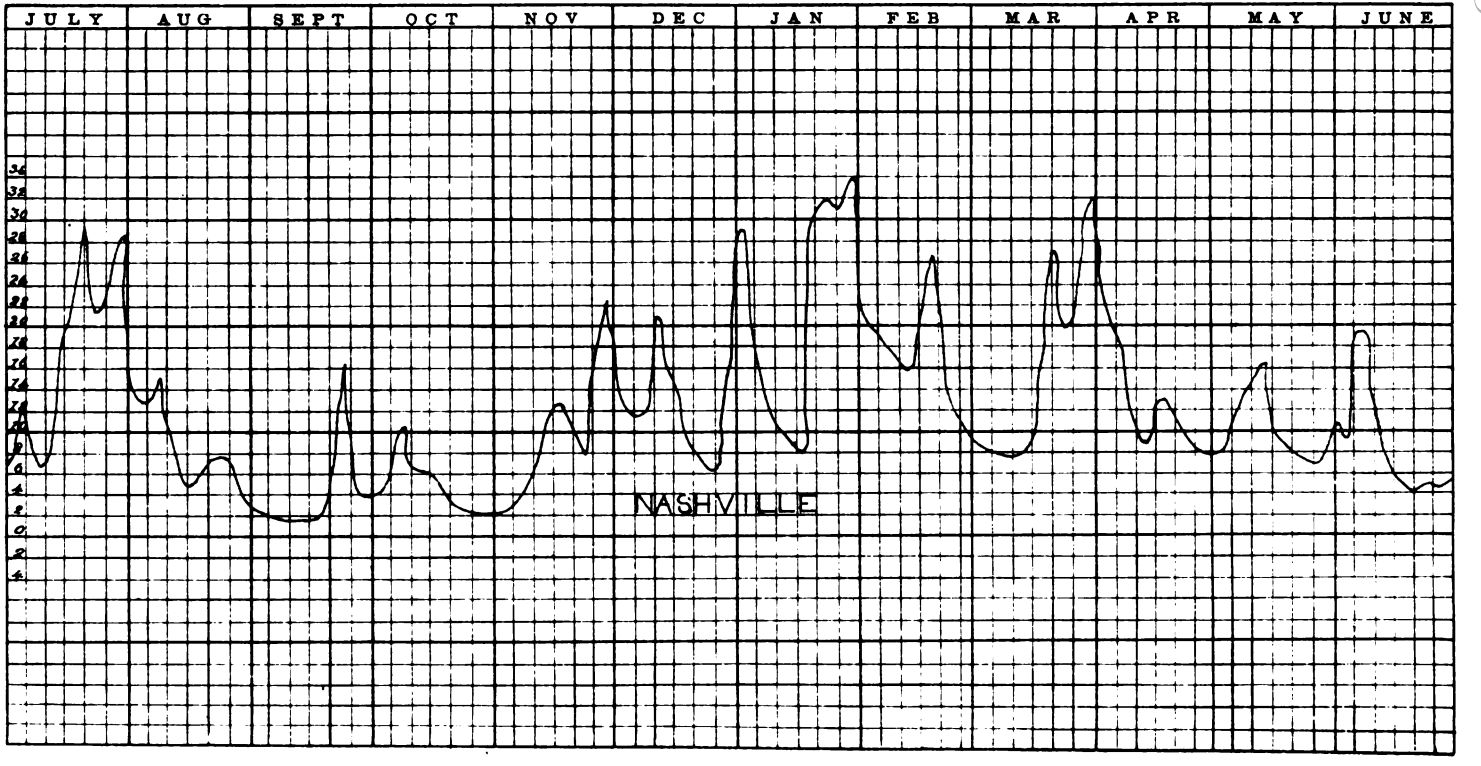
OSCILLATIONS CUMBERLAND RIVER, '75'76



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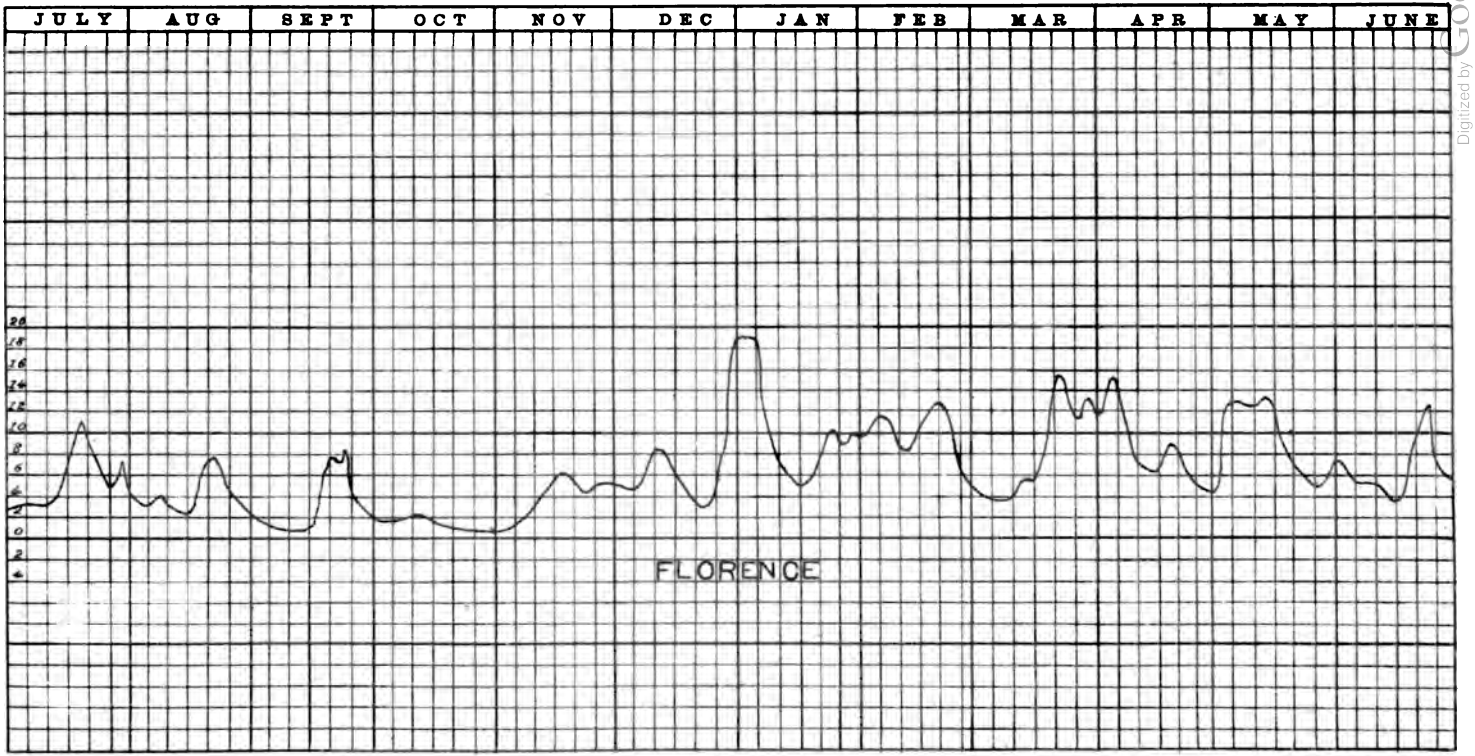
OSCILLATIONS TENNESSEE RIVER, '75 '76



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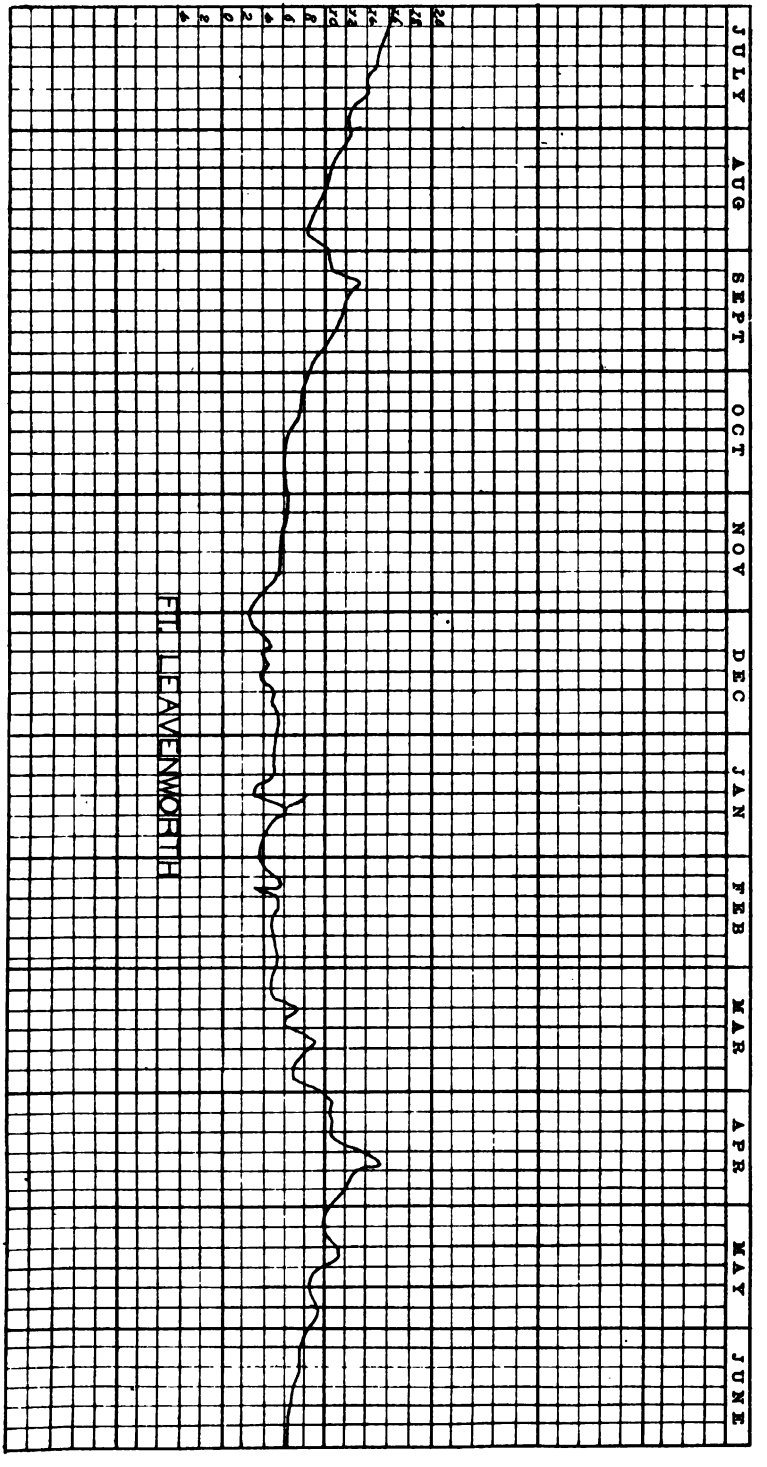
OSCILLATIONS MISSOURI RIVER, '75'76



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Generals Humphreys and Abbot's gauge.

Year.	High-water.		Low-water.		Authority.
	Date.	Gauge-reading.	Date.	Gauge-reading.	
1828	.....	47.7	.....	.....	Humphreys and Abbot, page 170.
1844	June 28	47.5	.....	.....	Do.
1849	April 26	47.7	.....	.....	Do.
1850	June 4	48.4	.....	.....	Do.
1858	June 26	48.3	Oct. 31	8.6	Humphreys and Abbot, Appendix B, p. 44.
1859	April 21	49.6	.....	.....	Humphreys and Abbot, Appendix B, p. 49.

Present gauge.

1862	.....	*51.10	.....	.....	Major Merrill, (Chief of Engineers' Report 1872, page 433.)
1867	.....	49.02	.....	.....	Do.
1871	.....	.....	Dec. 31	—0.38	Major Merrill, (water-gauge records.)
1872	May 2	39.50	Dec. 30	*—1.30	Do.
1873	May 29	40.60	Jan. 1	2.35	Do.
1874	May 2	45.70	Nov. 16	3.15	High-water, Major Merrill; low-water, Captain Benyaurd, (water-gauge records.)
1875	April 21	43.00	Nov. 13	8.10	Captain Benyaurd, (water-gauge records.)
1876	May 10	44.90	.....	.....	Do.

Standard high and low water to which gauge is referred, and oscillation at each gauge.

Station.	High-water.			Low-water.			Oscillation.
	Year.	Date.	Gauge reading.	Year.	Date.	Gauge reading.	
Alexandria, La	1866	.....	36.46	1872	Dec. 7	—2.60	39.06
Baton Rouge, La	1874	April 16	36.15	1854	.....	0.20	35.95
Cairo, Ill	1867	.....	50.97	1871	Dec. 24	—1.00	51.97
Carrollton, La	1874	April 16	15.70	1872	Dec. 27	—1.60	17.30
Florence, Ala	1867	.....	31.08	1872	Oct. 24	—0.76	31.84
Fort Leavenworth, Kans	1867	.....	22.06	1871	Nov. 30	0.00	22.06
Helena, Ark	1862	.....	46.40	1872	Dec. 26	0.00	46.40
Jacksonport, Ark	1867	.....	32.83	1872	Dec. 24	—1.10	33.93
Lake Providence, La	1862	.....	40.87	1872	Dec. 29	—3.85	44.72
Little Rock, Ark	1857	.....	31.00	1864	.....	0.00	31.00
Louisville, Ky., (upper)	1832	.....	40.76	1856	.....	1.09	39.67
Do (lower)	1832	.....	67.50	1856	.....	1.00	66.50
Memphis, Tenn	1867	.....	34.80	1872	Dec. 25	—0.95	35.75
Mouth of White River, Ark	1867	.....	46.80	1872	Dec. 28	0.00	46.80
Nashville, Tenn	1847	.....	54.67	.....	.....	0.00	54.67
Natchez, Miss	1859	May	49.00	1872	Dec. 15	0.00	49.00
Red-River Landing, La	1874	April 16	47.00	1872	Dec. 15	0.00	47.00
Rock Island, Ill	1870	April 24	16.71	1864	Sept. 2	0.00	16.71
St. Louis, Mo	1844	June 27	41.39	1863	Dec. 21	0.00	41.39
Vicksburg, Miss	1862	.....	51.10	1872	Dec. 30	—1.30	52.40

In addition to the above gauges there are others established upon the rivers, the improvement of which is under my charge, and the daily records kept in connection with those mentioned above.

Mr. Samuel McD. Vernon, chief engineer lower levee district of Mississippi, furnished me with the following data respecting the high-waters of 1875 and 1876 compared to that of 1874, along the Mississippi front. As a matter of record they are here inserted:

1875.—Australia, 17 inches below 1874.
Concordia, 18 inches below 1874.
Prentiss, 16 inches below 1874.

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1875.—Neblett's, 18 inches below 1874.
Cat-fish Point, 18 inches below 1874.
Greenville, 14 inches below 1874.
Eggs Point, 9½ inches below 1874.
Leota, 6½ inches below 1874.
Skipwith's, 4 inches below 1874.
Ben Lomond, 4¾ inches above 1874.
1876.—Australia, 2 inches below 1874.
Carson's, same as 1874.
Mouth of Arkansas River, 6 inches above 1874.
Neblett's, 6 inches above 1874.
Bolivar, 6 inches above 1874.
Cat-fish Point, 7 inches above 1874.
Chicot City, 9 inches above 1874.
Arkansas City, 9 inches above 1874.
Gaines's Landing, 9 inches above 1874.
Luna Landing, 7 inches above 1874.
Greenville, 7 inches above 1874.
Sunnyside, 6 inches above 1874.
Eggs Point, 4 inches above 1874.

Two cut-offs occurred during the high-water of 1876: that at Devil's Elbow 20 miles above Memphis the 25th day of March, and that at Vicksburg on the 27th of April.

I send herewith the gauge-records for the year ending June 30, 1876, and also hydrographs of the gauges on a small scale for the annual report. Hydrographs on a larger scale are also made but retained in the office.

Money statement.

Amount available July 1, 1875	$5,927 63
Amount expended during fiscal year ending June 30, 1876	4,390 37
Amount available July 1, 1876	1,537 26
Amount that can be profitably expended in fiscal year ending June 30, 1878	5,000 00

APPENDIX L.

ANNUAL REPORT OF MAJOR CHARLES R. SUTER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., September 23, 1876.

GENERAL: I have the honor to submit herewith my annual report upon the operations committed to my charge for the fiscal year ending June 30, 1876.

I am, general, very respectfully, your obedient servant,
CHAS. R. SUTER,
Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

L 1.

IMPROVING MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS.

At the date of my last annual report, it was expected that the funds available would be sufficient for 14 months of snag-boat work, but the necessity of paying a claim of $18,108.75 to N. G. Thorn, of Cincinnati

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contractor for the hull of the snag-boat J. N. Macomb, obliged me to reduce the time to 8½ months, of which 5 went to the Mississippi, 1 month to the Missouri, and 2½ to the Arkansas. The work as far as carried out in the Arkansas was satisfactory, but in the Missouri we were much impeded by the excessive high water. In the Mississippi, as much relief was afforded as could well be expected, as we had only one nearly worn-out boat to assign to the work. The iron snag-boat Macomb worked in the Missouri and Arkansas Rivers, and the snag-boat S. H. Long in the Mississippi.

MISSISSIPPI RIVER.

Operations in this stream extended over that portion of the river lying between Vicksburgh, Miss., and the head of Enterprise Island, above the mouth of the Illinois River.

The snag-boat S. H. Long was assigned to this field, and began work as soon as the summer flood had subsided. She left Mound City, Ill., August 22, 1875, and worked first up to Saint Louis, where she arrived August 31. Turning back from here and working down she reached Vicksburg October 4, and was again at Saint Louis on November 13. From this date until the 19th she worked by special request in the Upper Mississippi, removing some snags and one wreck. From November 19 to December 31 she worked between Cairo and Saint Louis, and after this time between Cairo and the mouth of White River. The boat was laid up and the crew paid off January 29, 1876.

Table of work done in the Mississippi River.

Name of boat.	Number of snags pulled.	Weight, in tons of 2,000 pounds.	Number of trees cut.	Drift-piles removed.	Wrecks removed.	Number of miles run.
S. H. Long	1,213	20,373.7	1,589	5	1	3,760

MISSOURI RIVER.

At the beginning of the fiscal year the snag-boat Macomb was laid up at Saint Charles, Mo., waiting for the river to fall sufficiently to enable her to accomplish good work. August 19 she started out, worked up the river to Brunswick, turned back on the 8th of September, and arrived at Saint Louis on the 25th of the same month.

Table of work done in the Missouri River.

Name of boat.	Number of snags pulled.	Weight, in tons of 2,000 pounds.	Number of trees cut.	Drift-piles removed.	Number of miles run.
J. N. Macomb	456	7,491.2	343	8	750

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ARKANSAS RIVER.

The snag-boat Macomb left Saint Louis for this stream December 2, 1875. She entered Arkansas River December 12, and worked over the lower portion (172 miles) of the river till the 31st January, 1876. She then started for Mound City, Ill., where she was laid up February 15, 1876.

Table of work done in the Arkansas River.

Name of boat.	Number of snags pulled.	Weight, in tons of 2,000 pounds.	Number of trees cut.	Drift-piles removed.	Number of miles run.
J. N. Macomb	545	8,960.3	1,274	5	1,272

Recapitulation of work during the fiscal year ending June 30, 1876.

Name of river.	Number of snags pulled.	Weight, in tons of 2,000 pounds.	Number of trees cut.	Drift-piles removed.	Wrecks removed.	Number of miles run.
Mississippi River	1,213	20,373.7	1,589	5	1	3,769
Missouri River	456	7,491.2	343	8	.....	750
Arkansas River	545	8,960.3	1,274	5	.....	1,272
Total	2,214	36,825.2	3,206	18	1	5,791

OPERATIONS FOR THE COMING SEASON.

The small amount of money allotted to this work ($50,000) will only allow of 7 months' snag-boat work, of which 5 will be devoted to the Mississippi, and 1 month each to the Missouri and Arkansas. The snag-boat Macomb, which is in first-rate order, will work 5 months, the remaining 2 months being assigned to the snag-boat R. E. De Russy.

I must again, in closing, beg leave to call your attention to the very great difficulties under which this work is carried on, owing to the worn-out condition of the greater portion of the working boats, and the difficulty of replacing them unless the appropriations are made on a more liberal scale than at present, for a few years at least. When this work was first started, 5 snag-boats, of various types, were deemed necessary, and were built or purchased. They were all kept at work to advantage as long as the necessary funds were provided for their maintenance, and the rivers were kept in better condition than had ever been done before. All these boats, however, were built of wood, and were therefore subject to a rapid deterioration, which was, of course, much hastened by the exceedingly hard usage to which they were necessarily subjected in the course of their work. The deterioration in their efficiency was first manifested in the increase of draught, due to the water-

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soaking of the wood-work of the hulls. This increase of draught rendered it so difficult and dangerous to work them in shallow streams like the Missouri and Arkansas, that as early as 1871 my predecessor, Lieutenant-Colonel Raynolds, recommended that the work should be commenced of replacing the wooden hulls by lighter and stronger ones of iron. As Congress made no special appropriation for that purpose, and as the work was imperatively necessary and admitted of no further delay, it was finally decided to build an iron hull for one of the snag-boats with funds drawn from the current appropriations. This boat, the J. N. Macomb, was completed in the fall of 1874, and has been at work since. She has answered our expectations in all respects, being of 6 inches lighter draught than the wooden boats were when new, and 1½ feet lighter than their present draught. Besides this, she is strong and handy and in every way a good working boat, and since she came out, in spite of 2 years' hard service, she has not required a dollar's worth of repairs. Meanwhile the wooden boats have gone on steadily deteriorating. One was wrecked in Arkansas River in 1872, and the others are so thoroughly worn out that it is no longer safe or even possible for them to perform the arduous work required of them. They need constant expenditures merely to keep them afloat; to bring them up to their original working capacity would require about $50,000 apiece, and no amount of repairs could diminish their draught of water, which, originally 4 feet, is now over 5. The iron boat, the Macomb, only draws 3 feet 6 inches, and, with the experience gained in her construction, there is no doubt in my mind that another similar boat could be built which would draw less than 3 feet. A smaller boat, with lighter machinery, also taken from one of the wooden snag-boats, could probably be got out on a draught of about 2½ feet. These two boats must be furnished if the work is to continue, and it is highly desirable that special funds should be provided for this purpose, as the appropriations made for several years past, even if entirely available for work, which was not the case, would have barely sufficed for the wants of the river commerce, even in its present greatly depressed condition. It should, moreover, be borne in mind that if the boats recommended are once built, they will probably be serviceable for 20 or 30 years or longer, and will meanwhile require but few and trifling repairs, so that every dollar appropriated annually for the work can be expended in the actual removal of obstructions.

For working in Upper Arkansas and Missouri rivers, and also in White and Saint Francis, it is very desirable that a small light-draught snag-boat should be provided. The only boat of this nature that we ever had was wrecked in Arkansas River in 1872, and has never been replaced. For this service I would recommend a stout iron-hulled stern-wheel boat similar to the one recommended in my report on the Upper Missouri River. (See Appendix M 3 of the Annual Report of the Chief of Engineers for 1875.)

It seems also necessary to call attention again to the great importance of the work accomplished by the snag-boats and to the necessity of keeping it up constantly and efficiently. No commerce can prosper which is constantly threatened and harassed by dangers against which no amount of skill and foresight can provide, and yet our western rivers are allowed to remain cumbered with snags, wrecks, and other obstructions which are a standing menace to navigation and only too frequently give rise to fearful accidents, accompanied by great loss of life and property. The snags can never be entirely eradicated as long as timber grows on the banks of the main streams or their tributaries; as the

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banks wash, the trees fall into the stream and are carried away to form obstructions in distant localities, or remain where they fell, fringing the shore until its gradual recession under the erosion constantly going on leaves them as formidable obstructions in the channel of the river. To remove these requires constant labor, as the high and low water channels rarely coincide, and both are equally obstructed; moreover, the channels at any stage are constantly shifting and exposing fresh obstructions. To render navigation safe, it is therefore necessary that the rivers should be constantly patrolled by boats which can remove these obstructions as fast as they appear, and, to a certain extent, prevent their formation by clearing the banks of timber which is in danger of falling into the river. No work that can be done will render such immediate and appreciable benefit to navigation as the removal of snags and wrecks from the rivers, and it must form a part of any plan of permanent improvement which may be adopted. I have submitted herewith an estimate of the cost of constructing the three snag-boats referred to, and it is most earnestly recommended that the amount required be appropriated at once.

I would also respectfully call your attention to the desirability of more specifically defining the aim and object of this appropriation in its title, in order that such sums as may be appropriated may go to the work itself and not be liable to be diverted for totally different purposes, as was done in the river and harbor bill of this year. I should, therefore, suggest that the title of the appropriation be changed so as to read, "For removing snags and wrecks from the Mississippi, Missouri, and Arkansas Rivers."

ESTIMATE OF AMOUNT REQUIRED FOR FISCAL YEAR ENDING JUNE 30, 1878.

For building one large iron-hulled snag-boat to carry machinery of one of the present wooden boats	$140,000 00
For building one small iron-hulled snag-boat to carry machinery of one of the present wooden boats	105,000 00
For building one small iron-hulled stern-wheel snag-boat	60,000 00
For repairing one wooden snag-boat, and fitting it up for wrecking purposes	50,000 00
For working expenses of five boats, 10 months each, at $4,000 per month	200,000 00
Total	555,000 00

Money statement.

Amount available July 1, 1875	$94,657 55
Amount expended during fiscal year ending June 30, 1876	90,998 57
Amount available July 1, 1876	3,658 98
Amount appropriated by act approved August 14, 1876	100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	555,000 00

L 2.

IMPROVEMENT OF WHITE RIVER ABOVE JACKSONPORT.

No further appropriations having been made for carrying on this work, the small balance left over has been expended during the last fiscal year in caring for the snag-boat and property belonging to this work, and in preparing the map and report herewith submitted.

As stated in my last annual report, a small surveying party was detailed to accompany the snag-boat Thomas Trunnel on her snagging

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trip in this river, to bring back some definite information relative to the stream, and, if possible, to prepare a plan for its permanent improvement. It was expected that the progress of the boat would be slow enough to allow of a continuous survey of the stream being made, but the unusual amount of high water and the severity of the winter made her operations so rapid and irregular as to preclude the possibility of accomplishing this object. It was also impossible to make the examination at low water, which is necessarily of the greatest importance in so small a stream. A map of the river, derived partly from instrumental surveys and partly from pilot-house sketches, was constructed, and a tracing thereof is submitted herewith.

From the information brought back by the party, it appears that the alluvial portion of White River ends about 20 miles above Jacksonport, which town is situated at the mouth of Black River. From this point up, the stream rapidly assumes the characteristics of a mountain torrent, the slope increasing rapidly and the valley becoming narrower. This latter is skirted by high bluffs, which, in some places above Batesville, are not more than half a mile apart. The numerous shoals are composed of gravel and coarse sand in the lower portions of the stream, while loose bowlders and rock in place form the principal obstructions above Batesville. Two miles below the latter place high-water mark reaches the top of the bank for the last time; above there the banks are 10 or 11 feet above this level. Floods are sudden and violent, and the high-water current is very strong, enabling the stream to move heavy gravel with facility. The low-water discharge is very small, and the current is too feeble to cut a channel through the gravel bars, which therefore remain as permanent dams, the current in the intermediate pools being sluggish. At some of these shoals, more especially those which contain rock, the great velocity of the current at low water is more of an obstacle than the actual lack of depth, some of them being, from this cause, almost impassable for the small class of boats used in the navigation of the stream. In the space of 130 miles from Jacksonport to the head of Buffalo Shoals, 63 shoals are reported, the minimum depth being 6 inches, and the minimum width of channel 50 feet. Between Jacksonport and Batesville, 39 miles, 19 shoals are reported, only 2 of which, however, approach the minimum dimensions stated above. As will be seen from the map, they become very numerous as Buffalo City is approached, and the slope becomes very heavy, upwards of 5 and 6 feet to the mile, the bottom being generally of rock. Buffalo Shoal is the worst, and is a very formidable obstruction. It must be improved before the upper portion of the river will be accessible at low stages. The low-water depth is only 6 inches, the bottom being of rock, covered with loose bowlders, and the shoal is a little over a mile in length. The very small volume of water available, and the serious nature of the obstacles to be encountered, renders it imperatively necessary that a careful continuous low-water survey should be made before plans or estimates can be prepared with any confidence. It is especially necessary that a continuous line of levels should be run, to enable a low-water profile of the stream to be constructed. An estimate for this survey is submitted herewith.

It is plainly evident that the plan of concentrating the discharge of the stream by spur or longitudinal dikes, with a view to scouring a low-water channel through the flood-deposits, is entirely impracticable here. The gravel is brought down by the floods in more than sufficient quantity to fill up annually any artificial channels made, and I do not think that the concentrated low-water discharge would be sufficient to scour

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through one of these bars, even if it could act for several seasons without further accretions to the deposit. Moreover, the rock could not be moved by this process, and the general effect would probably only be to increase the velocity of the current already objectionably great, with little or no increase of navigable depth. It therefore seems to me that the only method available is to leave the bars alone, and to seek merely for an increase of depth over them by diminishing the local slope.

The profile of the low-water surface of this river will undoubtedly show a series of nearly level reaches, separated by short and abrupt descents over the shoals. The average slope is probably not excessive, and, if maintained throughout, would give a good and deep channel; but there are many objections to seeking this result by cutting down the crest of the bars, even if the plan were otherwise feasible. These shoals form natural dams behind which the water is stored up during low water, and if they did not exist the stream would probably run dry at its lowest stages. The only plan practicable is, therefore, to flood the shoals at low stages to a navigable depth and width.

Of the various methods of accomplishing this object, the most obvious one is to create slackwater navigation by locks and dams, but this system, in addition to its costliness, has the disadvantage of rendering the stream impassable for boats which are too large for the locks, until the water rises sufficiently to let them go over the dams, or, roughly speaking, the river must rise more than is necessary for free navigation by about the height of the dams. In addition to this, the gravel brought down at high-water would eventually fill up or seriously shoal the pools above the dams, rendering frequent dredging necessary to keep up the proper depth. I have not the necessary data for submitting an estimate of the cost of improvement by this method, but it would necessarily be great.

Another method which would effect the same result is that of locks and movable dams, a system which has found much favor among French engineers, and has been recommended for several of our own streams. This system provides locks as in the ordinary slackwater navigation, but the dam, instead of being a permanent obstruction to the stream, can be removed in part to allow the passage of large boats, or can be entirely removed to permit the free discharge of the river in floods. Many of the objections to the first method are therefore removed in this one, but its costliness and the expense of operating it render it unsuitable for any stream, the value of whose commerce is not considerable.

The only method which seems feasible here is to break up the local slopes and distribute them over such distances as will reduce them to reasonable limits. This can generally be done by curving and thereby increasing the length of the channel, low dikes being run out alternately from each bank so as to concentrate the water pouring over the crest of the bar and hold it up until the requisite level is reached. These dikes will not increase the velocity of the current but rather diminish it, and as the flood will soon deposit gravel above and below them, it is believed that the curved channel-way thus set up will be reasonably permanent and reliable. Of course, in time it will be necessary to raise the dikes and perhaps to extend them, but at any rate the system will not simply result in transferring the bar from the head to the foot of the system of dikes, as almost invariably results when spur-dikes, designed simply to increase the scouring action of the current, are used. For want of definite information the estimate submitted herewith is necessarily only a rough approximation, but I think it is at least large enough, and a carefully-matured plan based on a proper survey would

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very probably reduce it. We were unable to obtain the extreme low-water discharge of White River, but from such observations as we have, I infer that it is approximately 1,000 cubic feet per second at Jacksonport, above Black River. This should enable us to maintain a channel having 75 feet available width and 2½ feet in depth, provided the velocity be reduced to 3 miles an hour, or 4.4 feet per second. The proper slope to give this velocity will vary according to the nature of the bottom, and the amount of curvature of the channel-way; it must be determined experimentally, but it will, I think, be found to approximate 18 inches to the mile.

Above Batesville, our information concerning the discharge is too meager to be depended on, but I apprehend that it would hardly be safe to count on more than 18 inches depth of channel-way with a width of 60 feet from the head of Buffalo Shoals to Sylamore, the velocity being increased to 4 miles per hour. From Sylamore to Batesville we can probably obtain a channel 2 feet deep and 60 feet wide, with the same velocity of 4 miles per hour. These minimum depths, it must be remembered, will be at extreme low water only and for probably only a few weeks in each year.

Below Batesville the dikes should be built of brush and stone, anchored with piles. All the material would have to be moved some distance, and the depth of water in which some of the dikes would be located is considerable. Above Batesville, rock would generally be alone needed, and could in most cases be procured on the spot; the depth of water, too, would be less.

I have, therefore, assumed that a linear foot of dike below Batesville would cost $8, while above that place the cost would be $5.50.

The following list gives the various places where work will probably be needed, together with the number of linear feet of dike deemed necessary at each place, and the estimated cost of the same:

From Jacksonport to Batesville.

Name of shoals.	Linear feet of dike needed.	Cost per foot.	Estimated total cost.
Black Island	800	$8 00	$6,400 00
Music Shoal	2,050	8 00	16,400 00
Haggletooth	1,050	8 00	8,400 00
Fortinberry	1,100	8 00	8,800 00
Beaven's Island	400	8 00	3,200 00
Childer's Island	2,050	8 00	16,400 00
McGuire's	450	8 00	3,600 00
Arnold's Island	1,000	8 00	8,000 00
Bill Magnes	1,150	8 00	9,200 00
Saffold's Island	2,500	8 00	20,000 00
Roaring Shoal	1,000	8 00	8,000 00
Col. Magnes	1,100	8 00	8,800 00
Cato	2,000	8 00	16,000 00
Buffalo Ford	1,000	8 00	8,000 00
Retherford's	2,000	8 00	16,000 00
Anglis	2,000	8 00	16,000 00
Beaver Island	1,600	8 00	12,800 00
Fatty Bread	3,200	8 00	25,600 00
Batesville Cut-Off	900	8 00	7,200 00
Amount			213,800 00

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From Batesville to Buffalo City.

Cornwall Shoals	2,000	$5 50	$11,000 00
Lone Willow Island	1,300	5 50	7,150 00
Wolf Shoals	1,200	5 50	6,600 00
Cackling Pullet	900	5 50	4,950 00
O'Neal's	850	5 50	4,675 00
Hess & Ivy	1,850	5 50	10,175 00
Caventer	1,200	5 50	6,600 00
Cagen Island Shoals 1, 2, and 3	2,000	5 50	11,000 00
Hidden Shoal	1,000	5 50	5,500 00
Spring Reach and Porter Hodges	1,500	5 50	8,250 00
Dilliard's	1,200	5 50	6,600 00
Twin Creek and Bishop's	1,800	5 50	9,900 00
Buck Island	825	5 50	4,537 50
Harris's	1,600	5 50	8,800 00
Langston and Lollygogue	1,800	5 50	9,900 00
Christwill	500	5 50	2,750 00
Fish Trap	1,800	5 50	9,900 00
Piney	700	5 50	3,850 00
Jim Jeffery's	1,800	5 50	9,900 00
Sam's and John Wolf	1,800	5 50	9,900 00
Race Course	800	5 50	4,400 00
Findley's	1,800	5 50	9,900 00
Tan Trough	800	5 50	4,400 00
Beck	1,500	5 50	8,250 00
Tom Morton	2,000	5 50	11,000 00
Hoosier Riffle	1,000	5 50	5,500 00
Rapides	1,600	5 50	8,800 00
Ezel	1,600	5 50	8,800 00
Three Chute	1,500	5 50	8,250 00
Robb	1,200	5 50	6,600 00
George Morton	1,600	5 50	8,800 00
Wyth Adams and Matney Riffle	1,800	5 50	9,900 00
Buckeye	800	5 50	4,400 00
Double Branch and McCubbin's	3,000	5 50	16,500 00
Mill Creek	800	5 50	4,400 00
Nellie's Apron and Buffalo Riffle	2,000	5 50	11,000 00
Amount			282,837 50

Buffalo Shoal.

Linear feet of dike needed	3,700
Cost per foot	$5 50
Estimated total cost	$20,350 00

From this it will be seen that the cost of improving the river from Jacksonport to Batesville is estimated at $218,800; from Batesville to Buffalo City, $282,837.50, and for Buffalo Shoals, $20,350. Adding 25 per cent. to these sums to cover engineering contingencies, they become respectively $273,500, $353,546.87, and $25,437.50. To this must be added the cost of necessary surveys, which will be $2,925 from Jacksonport to Batesville, and $6,825 from Batesville to head of Buffalo Shoals, or $9,750 for the whole distance.

There will, moreover, be needed at least twelve months' labor of a snag-boat in removing snags and other obstructions, which, at $3,500 per month, would amount to $42,000, and, allowing $6,000 for necessary repairs, $48,000.

The total cost of improvement would, therefore, be as follows:

RECAPITULATION.

From Jacksonport to Batesville		$273,500 00
From Batesville to Buffalo City		353,546 87
For Buffalo Shoals		25,437 50
From Jacksonport to Batesville, (for surveys)	$2,925 00	
From Batesville to head of Buffalo Shoals, (for surveys)	6,825 00	
		9,750 00
For twelve months' work of snag-boat, &c		48,000 00
Total		710,234 37

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As regards the necessity for this improvement, it may be said that the country bordering on this portion of White River is almost entirely dependent on water transportation, which, from the difficult character of the navigation, is very uncertain and costly. If the facilities for transportation and communication were increased, there would no doubt be a considerable emigration to this country, which embraces much valuable cotton and mineral lands. This is especially true of the section from Jacksonport to Batesville, to which it would probably be advisable to confine the improvement at first.

The amount of the estimate for surveys and snag-boat work, viz, $57,750, could profitably be expended during the first season.

Money statement.

Amount available July 1, 1875	$7,771 26
Amount expended during fiscal year ending June 30, 1876	7,771 26
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project	710,234 37
Amount that can be profitably expended in fiscal year ending June 30, 1878	57,700 00

L 3.

IMPROVING WHITE AND SAINT FRANCIS RIVERS.

No appropriation has been made for the improvement of these rivers since 1873, but as work is much needed there and will probably eventually be provided for, I submit herewith estimates for carrying it on. A small iron stern-wheel snag-boat should be built for this service.

ESTIMATE OF AMOUNT REQUIRED FOR FISCAL YEAR ENDING JUNE 30, 1878.

For building one stern-wheel iron snag-boat	$60,000 00
For operating same ten months, at $4,000	40,000 00
Total	100,000 00

Money statement.

Amount required for fiscal year ending June 30, 1878	$100,000 00

L 4.

SURVEY OF THE MISSOURI RIVER, AT THE POINT WHERE IT IS CUTTING INTO THE KANSAS SHORE, ABOVE SAINT JOSEPH, MISSOURI.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., January 25, 1876.

GENERAL: I have the honor to submit herewith a report on the "survey of the Missouri River where it is cutting into the bank at or near Saint Joseph, Mo.," made under my direction, by Mr. Boehmer, assistant engineer, in accordance with act of Congress approved March 3, 1875.

Mr. Boehmer's report and the accompanying maps give all the information needed for a clear understanding of the present state of affairs, and it only remains for me to recapitulate the main facts of the case.

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The channel of the Missouri River formerly followed the deep bend immediately above Saint Joseph, and flowed along the whole front of the town, caving the banks so badly that a series of small spur-dikes had to be built along the city wharf in order to save the lower part of the town. The result of this work was that the river was shifted over to the Kansas shore, which was very badly eroded, while an immense sand-bar formed in front of Saint Joseph. The water-way was then about 3,300 feet wide, much broken by bars, and the main channel was constantly shifting. Affairs remained in this condition until July, 1871, when the construction of a railroad-bridge at this point was determined on.

The accomplished engineer of the bridge company, Col. E. D. Mason, very rightly concluded that the construction and maintenance of the structure would be impossible unless the course of the river could be controlled and directed, and its waters confined to one particular channel.

The river at that time followed a tortuous channel past the east front of Elwood, and flowed obliquely over the proposed site of the bridge. Colonel Mason decided to fix the channel along the Missouri shore, and for this purpose a dike of brush and stone (Beard's dike) was run out across the channel from the Kansas shore. Its action was supplemented by a smaller dike farther down stream (Weaver's dike) and several small temporary works above. The effect of these dikes was to wash out the bar in front of Saint Joseph, transferring the river back to the Missouri shore, and the channel below the town has been stable ever since. Above the town it has shifted back and forth a good deal, until it has settled into the position shown on our map. After the construction of the bridge had been completed, it was found that rapid erosion had set in on the north side of the point opposite the city, threatening not only to change the whole regimen of the river, but even, if left unchecked, to cut off the whole point and leave the bridge on dry land. This danger had been foreseen, but Colonel Mason's death prevented the carrying out of any plan which he may have made to meet it. Three small dikes have been built along this caving shore, but they are too short and too far apart to offer much resistance to the fierce current to which they are exposed. The bank between them has been much eroded, and they are now in danger of being taken in rear and cut off from the shore altogether.

As before stated, the river follows the Missouri shore closely for some distance below, as well as above, the bridge. It has cut deeply into the Missouri bank below the town, and has, in consequence, been sharply deflected against the south side of the Kansas point. The erosion here has been very great, and the point, thus attacked on both sides, has been so much narrowed as to excite grave apprehensions lest it be washed away altogether. The north side of the Missouri point above Saint Joseph is also caving badly, and there is a possibility of a cut-off being formed here, the results of which would be disastrous in the extreme, and might even involve the destruction of the bridge. I caused this shore to be surveyed, so that subsequent measurements may determine what the rate of erosion actually is. Until this is known no work can of course be recommended here, but it seems to me that the checking of this erosion must ultimately form part of any plan of improvement. As regards the caving on the south side of the Kansas point, I do not think any work of protection is at present needed. The point of impact of the current is moving down-stream, and will soon reach the bluffs above Palermo, when the caving must necessarily cease. Should it, however, become excessive, the construction of a deflecting-

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dike may be necessary; but I do not anticipate that such will be the case. The question at present is therefore narrowed down to the protection of the north side of the Kansas point; and to effect this object, one of two things must be done—either the shore must be held where it now is, or else the river must be forced away from it. At this time only about three-fifths of the water follows the bend from Belmont down, the remainder is deflected by the rocky point above Belmont and comes down across the bar joining the other channel near the dikes. The result is that the right-hand stream is crowded in against the bank, and this fact, coupled with the very great velocity—over 5 miles an hour—accounts for the great erosion at this point and below. The scour is also very great, the water at the ends of the dikes being 50 feet deep at low-water. The present shore-line and the position of the channel are very good, and no change would be desirable if the erosion could be stopped. Nevertheless it seems a very direct way of averting the danger, and, as will be seen by his report, Mr. Boehmer favors it and submits a plan and estimate for its accomplishment. I do not, however, recommend it, because I can hardly think the means proposed by him would be adequate to insure entire success and also because I think that the cost of construction would much exceed his estimates, which are based upon Colonel Mason's experience at the other dikes. But it must be remembered that the cases are by no means alike, for at the site of Colonel Mason's work the channel was in a state of quite unstable equilibrium, and could be moved with comparative ease in any direction; but in the deep bend which we are now considering, the position of the channel is eminently a stable one, and it will be a matter of far greater difficulty and expense to move it than it was in the other case. The question of the depth to which the dikes will settle is a very important one, and there seems to be small hope for expecting them to stop much short of bed-rock. Beard's dike settled until it reached a stiff layer of clay, at a depth of 36 feet below low-water. The small dikes at the point we are considering have their ends in 50 feet depth at low-water. The bed-rock is probably about 25 feet deeper, and, judging from the amount of settling which has already taken place, the dikes must eventually reach it. This contingency might therefore greatly increase the cost of Mr. Boehmer's proposed plan, even if it proved adequate to accomplish the end proposed; and on this point, as I said before, I am in much doubt. If it were deemed preferable to advance the shore-line, I should recommend beginning at a point about 6,500 feet below Belmont and building out a series of dikes—as shown on the accompanying plan—short at first, and growing gradually longer, their heads reaching out to the desired shore-line, and their distance apart so proportioned as to protect the bank between them. This distance must be largely a matter of conjecture, our only source of information being the dike built by Mr. C. Shaler Smith, at Saint Charles, Mo., which was reported as protecting $3\frac{3}{4}$ times its length of shore, viz, $2\frac{1}{2}$ below and $1\frac{1}{4}$ above. Taking this as our standard, my estimate for the work would amount to $161,000, the cost per foot of dike being the same as assumed by Mr. Boehmer. Of course this cost as in his plan might be greatly increased by the settling of the dikes, and it is, moreover, not impossible that eddies might form between the dikes and cut away the bank as is being done at present, and then a revetment would be necessary. In view of the uncertainty attending the use of dikes, I am more disposed to favor the direct protection of the bank, at least at the point where it is caving so badly; and for this purpose I would recommend the use of substantial brush mattresses, of as large dimensions as can conveniently be handled, to

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be sunk against the bank and covered with a depth of stone sufficient to retain them in place and make them conform to the shape of the bottom. This protection should begin about 10 feet above low-water and extend out till the maximum depth is reached. The average width of this apron will be about 60 feet, and the length of shore to be protected 6,400 feet, which includes the work needed to secure the present dikes. The cost per foot of shore is taken at $23.44. This work will, I think, prove an efficient protection, and even if changes in the direction of the channel above or below should occur, the usefulness of the proposed revetment would still remain.

Whichever plan be adopted, other works may and probably will eventually be needed to control the river at this point; but it would be impossible to estimate on them until their necessity becomes apparent.

In conclusion, I must call attention to the fact that prompt action is needed in the case; for, if the dikes wash away, as seems very likely to occur, a very rapid erosion of the bank may be expected to follow, and the ultimate cost of works of protection will be greatly increased.

The following is the estimate of the plan which I propose, and the whole amount should be appropriated at once, in order that the construction may proceed with the dispatch absolutely necessary to secure success in work of this kind.

ESTIMATE

Revetment of 6,400 feet of bank:

$\frac{6400' \times 60' \times 2\frac{1}{2}'}{128}$ = 7,500 cords brush mattresses, at $3 per cord, (placed).....	$22,500
$\frac{6400' \times 60' \times 1\frac{1}{2}'}{9}$ = 64,000 cubic yards stone, at $1.75 per cubic yard, (placed).	112,000
	134,500
Excavation, contingencies, &c.....	15,500
	150,000

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORTS OF MR. MAX BOEHMER, ASSISTANT ENGINEER.

1.

SAINT LOUIS, MO., *July* 30, 1875.

MAJOR: I have the honor to submit the following report on the survey of the Missouri River, near Saint Joseph, Mo., ordered by act of Congress approved March 3, 1875, and assigned to my charge June 15, 1875.

The survey was made during the highest stage of water of the June rise of this season, the Saint Joseph Bridge Company's gauge reading 94 feet 6 inches. This gauge refers to a datum plane assumed at 100 feet below the high water of 1844. A discharge of the river taken at a stage of 93.25 shows the sectional area to be 38,187.2 square feet, the average velocity 5.02 feet per second, or 3.42 miles per hour, and the discharge per second 208,618.4 cubic feet.

An accurate survey was made of the point of land opposite Saint Joseph from Belmont to Palermo; the Missouri shore was established by triangulation. A line of levels run the entire distance of the shore-line gives a profile of the bank, and shows the average fall of the river at that stage to be 0.588 foot per mile.

The slope varies considerably at different points of this distance, it being greatest at a point where it is cutting into the narrowest place of the neck, in the bend above Saint Joseph. The river here falls 1.130 feet per mile. The velocity in the channel at this point is 5.55 miles per hour, which is a speed 0.68 mile per hour greater than the greatest velocity found at any other point along the entire shore. The width of the

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neck of land at the narrowest place was found to be 4,570 feet. From notes of previous surveys it is shown that since the spring of 1871 the river has cut away 420 feet in the upper and 810 feet in the lower bend, narrowing the neck 1,230 feet in 4 years. In the bend below Saint Joseph the river has not cut into the bank at all during the last high water, and little danger is apprehended of any further damage from this side, especially as the river is constantly and heavily cutting at a point above, on the Missouri shore, and thereby working for itself a straighter channel, away from the Kansas side. Should, at low water, the channel scour its way back and again hug the Kansas shore, a short dike built at a point marked A on the map will easily prevent the cutting and throw the channel toward the Missouri side.

Therefore, the necessity of protecting the banks applies only to the upper bend. Revetment of the Kansas shore, extending from Belmont to a point 3¼ miles below, is the most natural and surest protection to the bank, as it leaves the river in its natural bed. But as this is not the only remedy, and because of its immense cost, revetment appears to me to be out of the question.

I would therefore recommend the building of two dikes with strong shore connections, one at B and the other at C, as laid down on the map. The effect of these would be to throw the river into its old bed of 1871, the channel striking the Missouri shore 1¼ miles above the point where it strikes it now; this would lengthen the river, and, therefore, decrease its velocity at the very point where it is greatest at present. Not till the channel left the bed of 1871 did the river cut into the neck to any extent.

The benefit derived from protection of the banks, for the navigation of the river, is of importance only as, in a systematic improvement of our large western rivers, a fundamental rule should be to prevent a cut-off from taking place. The sudden fall and immense velocity produced by a cut-off is sure to make great changes below, and these cannot be controlled till the river has found its natural slope again.

The city of Saint Joseph, the Saint Joseph Bridge Company, and the railroads crossing the bridge are the parties interested in stopping the encroachment of the river; but so far only the bridge company have done anything to prevent it. They have built three spur-dikes in the upper bend, as shown on the map. These dikes are not long enough and too far apart to prevent strong eddies from forming between them and cutting away the bank rapidly. From their location and their insufficiently strong connection with the shore, I consider them liable to be swept away or separated from the shore during high water. Should this occur, there would yet be no imminent danger of a cut-off taking place; in fact, the improbability of it ever happening at all is sustained by the following reasons:

1. The point of land under question is of old formation, judging from its high elevation, (it was *not* overflowed in 1844,) and the heavy growth of hard timber upon it

2. Wells dug at different points show the existence of a stratum of stiff blue clay, 24 feet below the surface. Still the river at the upper bend is evidently trying to decrease its slope by lengthening its course; and this can only be done by either forcing it back into the old bed of 1871, or by letting it cut further into the neck.

I would recommend that before making estimates of the cost of any eventual structures during the contemplated low-water survey of the same locality, a few borings be made, to ascertain the nature of the bed of the river, as the continual sinking of the dikes proves the existence of quicksand in the upper bend.

I conclude with the expression of my obligations to the city engineer of Saint Joseph, Mr. Thomas Long, and to the Saint Joseph Bridge Company, who, through their superintendent, Mr. Robert Gunn, gave me all possible assistance in my work.

BEARD'S DIKE.

This dike was built in 1872, and finished in four months' time. It consists of trees from 30 to 60 feet long, laid with their tops up stream, and held in position by four rows of piles, driven 10 feet apart. A wall of riprap 12 feet wide and 3 feet high was built on top of the brush. The dike is 1,800 feet long, 60 feet wide at the base, and 30 feet at the top, with a depth of from 12 to 36 feet. The top of the riprap was built to an elevation of 88.

It contains 700 piles, 53,000 cubic yards of brush, 3,000 cubic yards of rip-rap; cost, including engineering, $32,600.

WEAVER'S DIKE.

This dike was also built in 1872, and is of similar construction, with the exception of its height. It was built 6 feet lower than Beard's dike, and only 150 feet near shore were raised to an elevation of 96. Its cost, including auxiliary dams and dikes, with engineering expenses, was $24,400.

SPUR-DIKES IN UPPER BEND.

These dikes were built in 1873, but their continual sinking, and the fact that the eddies between them are cutting away the bank and endangering their stability, makes

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a new protection of brush and riprap necessary against every succeeding stage of high water.

Original cost:

Piling, brush, and riprap	$7,020 39
Protection in 1874	5,367 57
Protection in 1875	6,197 35
Totat cost up to June 26, 1875	18,585 31

Very respectfully submitted.

MAX BOEHMER,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

2.

SAINT LOUIS, MO., *December* 13, 1875.

MAJOR: I have the honor to submit the following report on the second survey of the Missouri River, near Saint Joseph, Mo.

This survey was made during the month of November, 1875, at a stage of the river 10 feet 6 inches lower than that of the previous survey during high water in June, 1875, and covers the same ground, with an additional survey of the neck situated above Saint Joseph.

During the last three days of the work the river fell 2 feet 6 inches. This was caused by the gorging of the ice at the dikes in the upper bend. A survey at this low stage would have been more satisfactory, but as all the lines had been over and most of the soundings taken, I did not feel at liberty to incur the expense of a new survey. The average slope of the river in the 13 miles comprising the survey was determined and found to be 0.641 foot per mile. This is a little over half an inch per mile more fall than the river had at its high stage. The cause of this lies evidently in the fact that the range of the Missouri River between high and low water is about 20 feet less at Saint Joseph than at its confluence with the Mississippi. But the slope, although increasing, becomes more uniform as the river falls, owing to the greater uniformity of cross-section at low water. This shows itself very plainly at the dikes in the upper bend, where such great velocity and extraordinary fall of the river were noticed during the high stage. At the same place now the velocity is not greater than the average, and even 0.16 mile per hour less than that in the lower bend, where a speed of 2.47 miles per hour was found. A discharge of the river, measured at a stage of 83.5, gives the following figures:

Average velocity = 2.32 feet per second; 1.58 miles per hour.

Cross-section = 12,173.4 square feet.

Discharge per second = 28,541.6 cubic feet.

The changes in the river since its high stage in June are remarkable in some respects.

The proper bed of the river has narrowed down to a width of from 400 to 800 feet; the average velocity has decreased 1¼ miles per hour, while the difference between the greatest velocities observed at both stages is fully equal to 3 miles per hour. The bed of the river has changed greatly, as shown by the accompanying cross-sections, and especially so on the channel side of the bends. It is noticed that the more the river falls the closer the channel will hug the shore. The radius of the upper bend is about 8,200 feet, which is only 300 feet less than the radius of the entire bend in front of the city, although parts of the latter have radii up to 10,000 feet. The river in the lower bend turns at a greatly sharper curve, and there it has cut from 200 to 500 feet for a distance of a mile. But most of this is below the narrow part of the neck; still it has decreased the width of the same from 4,570 to 4,400 feet since the high water of June. Above, the neck has been left almost intact, owing to the dikes, which, although directly protecting only a short distance above and below them, still save the entire bend from severe encroachments. The direct protection of these dikes was apparent only below them, and there its extent was marked by a shallow ridge projecting 30 to 40 feet into the stream, and forming a division-line between the current below and the eddy above it. The length of this eddy was about three times the length of the dike in each case. The length of shore a dike of the length of X would protect cannot evidently be determined by isolated cases, as the members of which such equation is composed are so numerous and of such indefinite and inconstant nature that only by long and frequent observations can numerical values be established for them. One side of such equations would consist of values for the direction and velocity of the current, the

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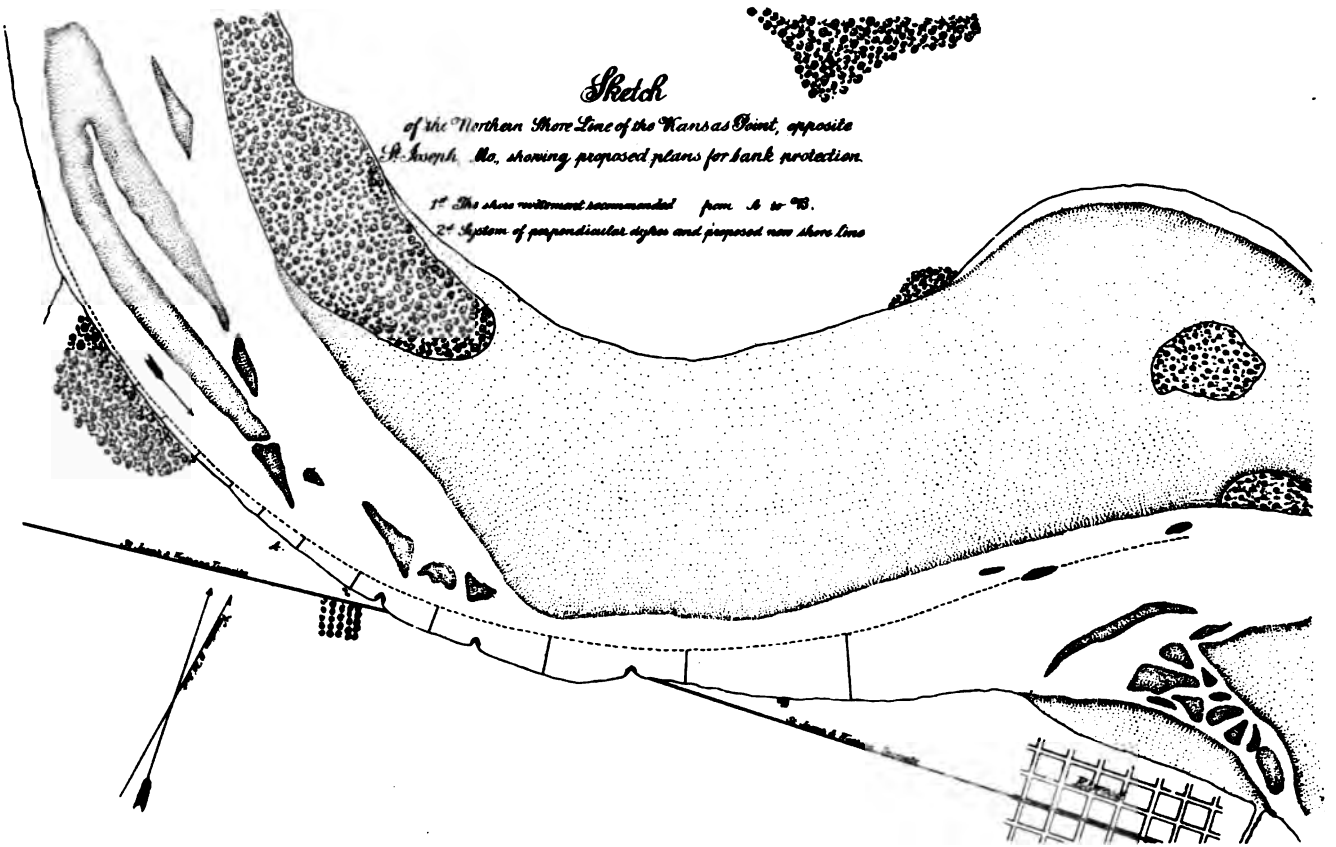
Sketch
of the Northern Shore Line of the Wansas Point, opposite
St. Joseph, Mo. showing proposed plans for bank protection.
1st The shore revetment recommended from A to B.
2d System of perpendicular dykes and proposed new shore line

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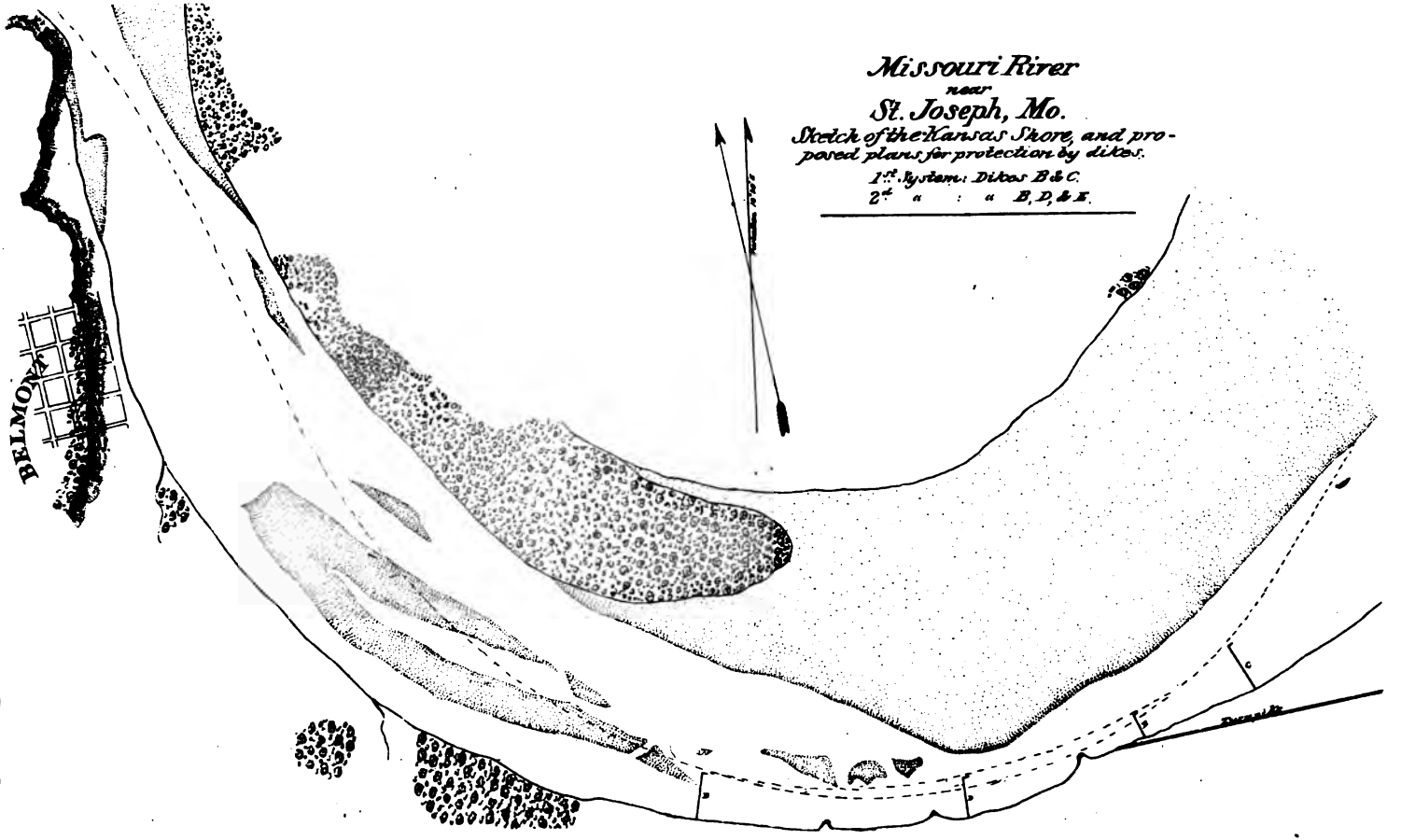

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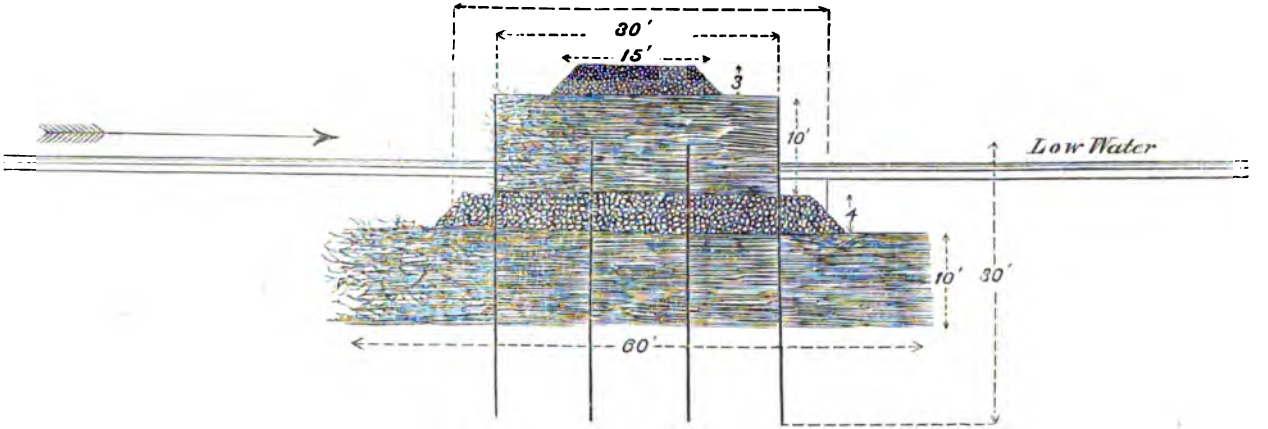

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nature and material of the bank and river-bottom, the longitudinal section of the dike, the radius of the bend, &c. From all information I could gather, and from my own observation, I cannot find any special cause for the encroachments on the neck at Saint Joseph. Without such special cause they must be explained by the nature of the stream itself. Very slight obstructions, as snags, or ice-gorges, may cause the formation of new bars which, growing continually, throw the channel farther and farther into shore. This happening above will necessitate similar changes below, and *vice versa*.

The neck above Saint Joseph is similar to the one opposite that town. Although its width is still 6,100 feet, it is continually decreasing, and, as its formation is less stable and its elevation lower, it is in at least as much danger of being cut off as the Saint Joseph neck. Therefore, permanent security lies only in the protection of both necks, unless by the breaking of the upper no serious damage should be done to the lower one, which is, to say the least, very improbable.

I see no reason to change the opinion expressed in my previous report concerning the protection of the neck at Saint Joseph. It is different in the neck above, where revetment seems to me the only protection possible.

* * * * * * *

I am happy to bring to your favorable notice the willing and efficient services of Mr. Frank Hotchkiss as my assistant in both surveys.

Very respectfully,

MAX. BOEHMER,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

3.

SAINT LOUIS, MO., *January* 21, 1876.

MAJOR: As an appendix to my previous reports, I herewith submit estimates of cost of structures for the protection of the Kansas shore in the bend above Saint Joseph, Mo.

Estimates are subjoined for two different plans.

The first consists of 2 dikes, (B and C on the map,) 600 feet long each; the second of 3 dikes, (B, D, and E,) respectively 600, 500, and 300 feet long.

The probable effect of the first system will be to throw the channel away from the Kansas shore near and above Elwood, while from Belmont down to the first dike the channel will return to its old bed nearer the Missouri shore.

The shore between the proposed dikes will be sufficiently protected by the spur-dikes already built, although the river here will have received a sharper curve by the changes.

The second system is free from this latter fault, and is, therefore, recommended as the better plan, although its cost is about 25 per cent. greater.

The estimates are based on the same cross-section for all dikes, as shown in the sketch below, and allowance is made for very strong heads and shore connections.

1ST SYSTEM—TWO DIKES.

Dike B:	
320 piles, 30 feet long, at 18 cents per linear foot	$1,728 00
5,600 cords of brush, at $2.50	14,000 00
5,400 cubic yards of stone, at $1.75	9,450 00
	25,178 00
Engineering and superintendence, 10 per cent	2,522 00
Cost of dike B	27,700 00
Dike C:	
Cost of dike C	27,700 00
Total cost	55,400 00

2D SYSTEM—THREE DIKES.

Dike B:	
Cost of dike B	27,700 00

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Dike D:			
280 piles	$1,512 00		
4,800 cords of brush	12,000 00		
4,700 cubic yards of stone	8,400 00		
	21,912 00		
Engineering and superintendence, 10 per cent	2,188 00		
	24,100 00	Cost of dike D..	24,100 00
Dike E:			
200 piles	1,080 00		
3,300 cords of brush	8,250 00		
3,800 cubic yards of stone	6,650 00		
	15,980 00		
Engineering and superintendence, 10 per cent	1,620 00		
	17,600 00	Cost of dike E..	17,600 00
Total cost			69,400 00

Very respectfully,

MAX BOEHMER,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

APPENDIX M.

ANNUAL REPORT OF COLONEL J. H. SIMPSON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., August 26, 1876.

GENERAL: I have the honor to submit herewith my annual report for the fiscal year ending June 30, 1876.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

M 1.

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

BETWEEN THE ILLINOIS AND MISSOURI RIVERS.

The appropriation bill approved March 3, 1875, required that $15,000 should be expended within the above limits. As the dam at Alton Slough had been completed under previous appropriations, it was decided to commence the construction of a dam at Piasa Island. Bids were received for this work June 29, 1875, of which an abstract accompanied my report for the fiscal year ending June 30, 1875. The high

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stage of water prevented the commencement of operations until the latter part of August. Construction was commenced August 26, and continued until November 30. The dam is located about 600 yards below the head of Piasa Island, and extends from the island to the Missouri shore, a distance of 3,070 feet.

The shore connections were secured by a longitudinal wall of riprap, and revetment of the slope extending 100 feet below the line of the dam. The foundation of the dam is completed, except for a space of 400 feet near the middle of the stream, which was occupied by a high bar. At the close of the season the apron had been raised to the height of low water, and nearly the whole volume of water was compelled to pass through the Illinois chute. The water over the bar near the head of the island was reported to have deepened from 4½ to 8 feet. It will be necessary to complete the prism of the dam the coming season, and to fill the interval left open last year. It will also be necessary to revet the head of the island, which is now exposed at low stages to a rapid current. Estimated cost to complete the dam, $25,000. The expenditures on account of this dam were:

518 piles	$2,158 62
677.4 cords brush	1,016 10
158.51 cubic yards spalls	31 70
7,928.27 cubic yards riprap	9,276 07
Engineering and contingencies, 29.9 per cent	3,728 24
	16,210 73

The river and harbor bill approved August 14, 1876, requires the further expenditure of $15,000 between the Illinois and Missouri, of which the greater portion, $13,500, it is proposed to expend in the construction of this dam, leaving an estimated balance of $11,500 to be provided by future appropriations.

ALTON DAM.

This work has remained in the condition reported last year, except that the eddies below the dam have cut into the bank below the revetment and are enlarging. The west abutment was partially repaired last fall with 162.31 cubic yards of riprap, at a cost of $197.30. Repairs and extension of the abutments will be necessary the ensuing year, at an estimated cost of $1,500. The repairs required are to be made from the funds provided in the river and harbor bill of the present year; and it is not anticipated that further funds will be needed for this work.

The cost of this work to date has been:

6,730 cubic yards excavation	$1,682 50
584 piles	1,223 80
1,543.82 cords brush	3,401 80
12,108.89 cubic yards riprap	17,126 15
5,637 cubic yards spalls	5,637 00
Labor	739 45
Engineering and contingencies, 5.2 per cent	1,557 75
	31,368 45

Original estimate, $40,000.
The length of the dam is 996 feet.

SAWYER BEND.

Work at this locality has been limited to repairs, using—

1,040.31 cubic yards riprap, at cost of	$1,269 18
Engineering and contingencies	197 50
	1,466 68

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The appropriation of March 3, 1875, did not warrant the extension of this work last year, and it was thought that delay would not be a disadvantage, as the bend above was being cut out to a more favorable shape. The cutting has progressed now as far as is desirable, and it is hoped that provision will be made for the continuation of the work at an early date.

To carry out the recommendation of the board contained in their report of April 13, 1872, at this point requires the extension of the protection 4,365 feet. The original estimate was $142,211.62, of which $91,981.12 have been expended, leaving $50,230.50 remaining to be appropriated, which will be sufficient to complete the work, if made available at once. The small amount appropriated by the bill for the present year will not warrant the continuation of work at this locality. The balance of estimate, $50,230.50, is therefore to be provided by future appropriations.

The account with this work is:

31,975 cubic yards excavation	$5,755 50
Dredging	11,195 91
630 piles	3,439 37
4,942.12 cords brush	14,113 40
30,780.80 cubic yards riprap	40,746 00
2,622.01 cubic yards revetment	4,850 72
1,210.37 cubic yards spalls and macadam	1,391 48
Labor	1,521 50
Engineering and contingencies, 10.8 per cent	8,967 24
	91,981 12

LONG DIKE NEAR VENICE.

This work was partially restored to its condition previous to the injury by ice in the spring of 1875. Complete repairs were prevented by the high stage of water in July and August of 1875. There has been expended during the fiscal year for—

2,125.85 cubic yards riprap	$2,593 53
Engineering and contingencies	198 00
	2,791 53

Repairs will probably be required to keep this dike at its proper height during the coming year to the amount of $2,500.

The account with this work is:

517 piles	$3,364 55
1,944.63 cords brush	4,893 06
18,618.71 cubic yards riprap	24,668 45
Engineering and contingencies, 10.4 per cent	3,415 79
	36,341 85

for raising 1,460 feet of old dike, extending 600 feet, and construction of T-head. In the original project the extension of two other dikes was joined with this, in an estimate of $197,323.90. These dikes it is not advisable to extend at present, nor until the rights of riparian proprietors are examined and adjusted, to avoid claims for heavy damages. No work can be done here the present year.

HORSETAIL BAR.

The favorable results reported last year at this locality were not continued during the season of low water, 1875. The crossing which had given trouble in previous years was reported last year to have deepened

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about 2 feet, which deepening it was hoped might be permanent, an expectation which was but partially realized. During the high water of the summer of 1875, very extensive erosions were made from the head of Arsenal Island and from the Illinois bank in Cahokia Bend; the eroded material from these sources passed the narrow section of river in front of South Saint Louis, (Carondelet,) and was dropped in the upper part of the wide expanse called Horsetail. This deposit caused an obstruction which, though called by the old name, is located 1½ miles above the bar whose removal had been the object in previous years. At the locality of the new obstruction the depth had previously been at least 6 feet at all stages. This deposit filled the whole bed of the river to the height of 8 or 10 feet above the normal low-water plane. The dikes which had been built in the vicinity were raised to the height of 8 feet above low water; therefore, when this new deposit was made the dikes were below its general level, and could exert no influence upon the currents until the bar was washed down to the level of the dikes. When this occurred the channel first cut out a crooked course around the head of dike No. 1, which was difficult to follow; later the channel deserted this position, and, after opening temporarily at several points in the width of the river, at the end of the season crossed to the Illinois Shore and followed it down to dike No. 3; then, turned aside by the dike, it crossed back to the Missouri Shore. After it had established itself in this location, there was little trouble on account of depth, but the channel was crooked and difficult. The increased depth in the final location proves that the channel had previously been shoal only because it was continually shifting its position in the recently-deposited bar, whose uncompacted material yielded more readily to the current at the side than at the bottom. These movements of the new bar involved the removal of vast quantities of material, which was again deposited at the lower end of the reach, and occasioned some trouble on the lower crossing. The condition of the navigation showed the necessity of the immediate construction of dike No. 2, which was commenced in October, upon the site indicated in the project submitted April 28, 1873. The late date of its commencement did not permit it being advanced far enough to exert any appreciable influence last fall; but it is hoped that it will exert a beneficial effect the present year, although it is 500 feet short of its contemplated length of 1,800 feet.

In order that the dikes should be able to exert an influence upon the channel at the higher stages, and prevent the recurrence of the conditions of last year, it will be necessary to raise them at the shore ends to the height of a mean stage, and make the profile a slope from the bank to the outer end of the dikes. This change in the profile was indicated by the experience of previous years; that of last year proves that the immediate execution of the change is necessary. A survey of the locality was made at low water in December, 1875, which showed that there had been an accumulation of sand on the Illinois side held by the dikes, which corresponded closely with the line of improvement. This sand-bar was nearly of the height of the dikes 3, 4, and 5, and extended from No. 3 to the head of Carroll's Island. Nos. 4 and 5 being nearly buried, must be credited with having accomplished all that could be expected of them in their incomplete state.

The high water in July, 1875, afforded a severe test of the experiment at dike No. 5, mentioned in the report of last year, as the water flowed over the revetted sand embankment to the depth of 5 feet without injuring the dike; but, on the contrary, the dike was strengthened by deposits. At the junction of the earth embankment with the riprap

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part of the dike, near the edge of the dry bar, the dike was undermined, and settled about 15 feet as a maximum, the breach being about 210 feet wide; this breach was filled, and the earth embankment extended 200 feet inshore to a connection with the levee. The embankment now slopes from the height of the levee to 8 feet above low water in a distance of 1,300 feet. It was contemplated to extend this dike last year to its full length, but the site became inaccessible in September, and the extension was not begun. A part of dike No. 3 settled during the high water, and required repairs; the settlement was confined to the 400 feet nearest the Illinois shore, where, when the dike was commenced, the water was 20 feet or more in depth. The bottom here was light sand, deposited probably in a deep channel at some recent period. The settlement being in deep water, a large amount of material was required to close the breach. Dikes 1 and 4 were not injured, and required no repairs.

During the spring and summer of 1876 the high-water deposits have been similar to those of 1875. At the date of this report the only practicable channel crosses dike No. 1 about midway of its length, the outer end of the dike being buried in a reef. It is probable that the first channel cut out will be around the end of the dike; if so, the history of last year will be repeated. The completion of dike No. 2 and raising of No. 1 is an immediate necessity; it is therefore proposed to apply $50,000 of the present appropriation to work at this locality.

The expenditures on account of the several dikes at Horsetail Bar during the fiscal year ending June 30, 1876, were:

For dike No. 2:		
254 piles	$1,087 86	
1,405.14 cords brush	2,107 70	
9,296.83 cubic yards riprap	10,924 19	
114 hours' labor	22 80	
Engineering and contingencies	1,421 48	
		$15,564 03
For dike No. 3:		
5,218.81 cubic yards riprap	$6,174 04	
Engineering and contingencies	513 41	
		$6,687 45
For dike No. 5:		
3,900.58 cubic yards riprap	4,601 01	
182.32 cubic yards embankment	18 23	
Labor	38 30	
Engineering and contingencies	580 00	
		5,237 54
		27,489 02

Which, deducted from estimate given in transportation-route report, January 23, 1875, of $100,000, leaves $72,510.98 to be appropriated.

The total cost of the works at this locality has been:

Dike No. 1, 1,171 feet long, with T-head, 200′ × 80′:		
510 piles	$2,953 33	
1,755.25 cords brush	5,183 00	
12,232.49 cubic yards riprap	17,208 11	
91.29 cubic yards spalls	127 81	
Engineering and contingencies, 5.5 per cent	1,401 58	
		$26,873 83
Dike No. 2, 1,300 feet long:		
254 piles	1,087 86	
1,405.14 cords brush	2,107 70	
9,296.83 cubic yards riprap	10,924 19	
114 hours' labor	22 80	
Engineering and contingencies, 10.05 per cent	1,421 48	
		15,564 03

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Dike No. 3, 1,375 feet long:		
249 piles	1,263 43	
371.8 cords brush	1,366 48	
27,999.56 cubic yards riprap	40,896 00	
Labor	329 62	
Engineering and contingencies, 8.3 per cent	3,651 27	
		47 506 80
Dike No. 4, 2,070 feet long:		
342 piles	1,483 84	
792.26 cords brush	2,804 60	
20,876.18 cubic yards riprap	31,071 07	
Labor	75 00	
Engineering and contingencies, 9.7 per cent	3,213 66	
		38,648 17
Dike No. 5, 2,400 feet long:		
242 piles	1,063 65	
743.8 cords brush	2,087 88	
9,610.98 cubic yards riprap	13,618 73	
8,100.32 cubic yards embankment	1,977 24	
Engineering and contingencies, 8.8 per cent	1,651 55	
		20,399 05
Total		148,991 88
Unappropriated balance of estimate		72,510 98
Total estimated cost of present project		221,502 86

DAM AT FORT CHARTRES ISLAND.

The work at this point was commenced in the fall of 1874. During the last fiscal year the body of the dam was filled in to the height of 8 feet above low water, except for 300 feet at the west end. It is estimated that 6,500 cubic yards of riprap will complete the dam, at a cost of $9,750. The dam is 1,592 feet in length, and has received material during the fiscal year as follows:

28 piles for moorings	$100 94
10,648.6 cubic yards riprap	15,879 88
1,218.8 cubic yards spalls	1,267 55
Engineering and contingencies	1,061 86
	18,310 23

The total cost to date has been:

504 piles	1,957 34
1,057 cords brush	2,081 60
18,625.2 cubic yards riprap	28,588 24
1,218.8 cubic yards spalls	1,267 55
Engineering and contingencies, 8.8 per cent	2,993 13
	36,887 86

It is proposed to complete the dam the present year.
The original estimate for work in this vicinity was $75,000.

TURKEY ISLAND DAM.

This dam was commenced in the spring of 1875, and was continued until the chute became inaccessible early in the fall. The chute has been rapidly filled by the river during the last two years. The dam is 1,834 feet in length, and at the time work was suspended stopped the water from passing at the stage of 7 feet above low water. It having been built upon shallow foundations, considerable settlement is liable to take place. Without settlement, it is estimated that 7,000 cubic yards of riprap will complete the dam, at cost of $11,000.

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Material has been used during the year as follows:

13 piles, for moorings	$67 78
278.3 cubic yards spalls	289 43
6,355.9 cubic yards riprap	9,560 65
Engineering and contingencies	681 24
	10,599 10

The total cost of dam is:

41 mooring-piles	$206,98
10,935.8 cubic yards riprap	18,262 45
278.3 cubic yards spalls	289 43
Engineering and contingencies, 14.9 per cent	2,806 60
	21,565 46

Owing to the late date of the passage of the river and harbor bill, it will not be practicable to complete the dam this year, as it is inaccessible at low stages; but it is necessary to continue the work so far as possible.

Original estimate for works in this vicinity was $100,000.

LIBERTY ISLAND.

This locality has, for several years, been a great obstacle to navigation. The act approved March 3, 1875, authorized the application of $15,000 to the locality. It was contemplated to close the Missouri chute by a dam, and one was located and the construction of the west abutment begun; but after the high water of July and August passed it was found that the Illinois chute was unnavigable, and that the tendency of the channel was to desert it altogether. It was therefore decided to suspend work on the dam and devote the season to a revetment of the Missouri bank opposite and above the head of the island to preserve a direction which would be favorable if the channel should take the Missouri chute, and prevent the cutting progressing so far as to render a return to the Illinois chute impossible. On engineering grounds alone the Missouri chute is fully as desirable, when cleaned of snags and wrecks; but the small town of Rockwood is situated on the Illinois chute, and its interests should not be sacrificed. It is therefore deemed advisable to wait another year before deciding which chute should be closed.

In the protection of the bank there was expended:

12 piles, for moorings	$43 27
9,596.6 cubic yards riprap	14,298 93
720.2 cubic yards spalls	749 01
Engineering and contingencies, 9.3 per cent	1,406 47
	16,497 68

For the abutment of the dam:

19.7 cubic yards spalls	$20 49
3,029.9 cubic yards riprap	4,646 21
Engineering and contingencies, 8.3 per cent	387 21
	5,053 91

The excess over $15,000 was taken from the portion of the appropriation not specifically located by Congress.

It is very necessary that the revetment of the bank should be raised throughout the portion commenced last year, which covers a front of 3,774 feet, and the protection should be extended 2,700 feet to a connection with the dam abutment now in place, at an estimated cost of $26,610.

The original estimate for the locality was $100,000.

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DEVIL'S ISLAND.

The high water of July and August, 1875, caused considerable change in the condition of dike No. 1 after the annual report was written. The foundation of the dike had been completed in the fall of 1874, and the dike raised to the height of 6 feet above low-water mark; but the foundation rested on a sand-bar whose surface for a great part of the length of the dike was above low-water mark. During the spring and summer the extensive dry bar above and attached to the opposite bank moved down stream so far that when the water fell the current drew across the dike; as a consequence, the foundation settled. The greatest change was near the shore, where the dike settled from 6 feet above to 30 feet below low water. Near the middle the change was slight, and the outer end was sunk irregularly, varying from 6 to 15 feet. The strongest current being along shore, the bank above and below the dike was considerably eroded, and it was deemed necessary to revet the bank for a distance of 1,000 feet above the dike; of this distance 625 feet was protected during the season. In this protection a single mattress of brush was sunk, 495 feet in length by 50 feet in width, containing 566.14 cords brush. The success of this experiment justifies the expectation of a material cheapening of the cost of protective works.

The channel last year passed close around the end of the dike, and as the bar above was likely to continue to move down stream, it was not deemed advisable to repair the outer end of the dike. The breach near shore was filled nearly to the final profile.

The foundation of dam No. 1, in the chute between Devil's and Picayune Islands, was completed, the east-shore connection secured, and considerable progress made in filling the body of the dam. When inspected in June last it was apparently undisturbed, and the chute appeared to be filling.

At dam No. 2, in the chute between Picayune Island and the main Illinois shore, no work was done except to place material previously delivered.

The expenditures during the year were:

Dike No. 1:		
566.14 cords brush	$1,986 53	
3,034.51 cubic yards spalls	3,130 24	
17,180.09 cubic yards riprap	25,951 32	
Excavation and labor	456 56	
Engineering and contingencies	1,638 10	
		$33,162 75
Dam No. 1:		
Excavation and labor	$548 36	
652.85 cords brush	2,245 39	
2,544.28 cubic yards spalls	2,854 41	
9,758.72 cubic yards riprap	15,288 57	
167 piles	620 80	
Engineering and contingencies	829 10	
		22,386 63
Dam No. 2:		
Labor	$38 50	
		38 50
		55,587 88

The total cost of these works is:

Dike No. 1, 1,000 feet in length and 625 feet shore-protection:		
458 piles	$1,374 00	
2,043 cords brush	6,802 44	
21,601.43 cubic yards riprap	35,556 10	
3,034.51 cubic yards spalls	3,130 24	
Excavation and labor	456 56	
Engineering and contingencies, 6.5 per cent	3,080 52	
		$50,399 68

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Dam No. 1, length 1,750 feet:		
528 piles	$1,703 80	
2,291.86 cords brush	7,910 95	
15,443.79 cubic yards riprap	26,852 80	
2,544.78 cubic yards spalls	2,854 41	
Excavation and labor	548 36	
Engineering and contingencies 8.1 per cent	3,213 74	
		43,084 06
Dam No. 2, length 350 feet:		
104 piles	$315 06	
682.98 cords brush	1,627 73	
2,982.34 cubic yards riprap	6,211 24	
Excavation	38 50	
Engineering and contingencies 15.7 per cent	1,286 65	
		9,479 18
		102,963 10

The total estimate for works in this locality was $250,000, leaving for future operations $147,036.90, of which $47,036.90 will be required to complete the works already begun; and of this sum it is proposed to spend $30,000 the present year.

CLOSING CAHOKIA CHUTE.

Although the closing of this chute is partially provided for in the new river and harbor bill, approved August 14, by a distinct clause and a specific sum, the work itself is part of the general scheme for the improvement of the Mississippi River, and bears a very important relation to the improvement of the navigation. When the special report was made, under date of January 23, 1875, (see Report of Chief of Engineers for 1875, page 497, part 1,) there was no apparent reason for the opinion that the immediate closure of the chute was necessary in the interests of navigation. After the date of that report a rapid cutting away of the head of the island commenced, which has progressed rapidly since, and furnished material for deposits which greatly obstructed navigation at Horsetail Bar. This erosion still continues. The head of the island has been cut away so much that the head is now nearly one-half mile farther down stream than at the date of the map accompanying the report. A large area of the highest part of the island has disappeared. It is now of the greatest importance that this erosion should be stopped and the chute closed. The appropriation just made will all be required to revet the island to secure it from further erosion and the consequent destruction of the site for a dam. The dam itself must await further appropriations. The original estimate did not include the cost of protecting the island, the necessity for which was not then apparent. The estimate of funds required for the dam remains, $75,000, all of which should be granted in one appropriation, as the work is not divisible.

KASKASKIA BEND.

This locality was made the subject of a special report, dated April 28, 1876, in which an estimate was submitted amounting to $42,000. The late bill requires that $5,000 should be expended at this locality. It is very difficult to put in language all the reasons that conspire to render the application of small sums to the control of a mighty stream like the Mississippi wasteful. I will endeavor to make this case illustrate the general principle. The extent of front that it is necessary to protect is 6,000 feet; the estimated cost is $7 per foot, which would suffice if all the work was provided for at once. Undertaken with the sum of $5,000,

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the cost would need to be taken at $10 per foot on account of limited amount of work; therefore 500 feet would be the extent of protection. Five hundred feet of the length of one of the sweeping bends of the Mississippi is comparatively but a patch, and practically exerts no controlling influence above or below; the protected front may be held, but the bank retreats both above and below, and the projection becomes a disturbing element, which, by creating eddies, intensifies the destruction in its vicinity, when a longer firm front would by virtue of its length restrain the eddies and deliver the current smoothly at the lower end. The application of so small a sum cannot therefore be made where the need is greatest, but must be located at the very head of the caving bank, entirely above the point where the destruction is active, and cannot extend far enough to afford any relief to the interests endangered, and whose influence has obtained the appropriation. Since the special report was made the caving has continued, and at the apex of the bend the caving amounts to 250 yards. From the direction of this recent caving the danger of a junction with the Kaskaskia is less imminent than when the report was written, the apex being now below the point of nearest approach of the two rivers. If this work is commenced under the present appropriation, its continuation next year becomes a necessity. If a special sum is to be set apart for its continuation it should not be less than $25,000 to accomplish useful results.

PROTECTION ABOVE CAIRO.

A special report upon this locality constitutes House of Representatives Executive Document 126, 44th Congress, first session. The estimate there given for the protection of the Illinois shore is $172,500, of which $30,000 is provided for the present year, which it is proposed to apply at the point of greatest danger to the navigation. For the continuation of this work, at least $30,000 should be provided the coming year.

I would respectfully call attention to the fact that the estimates for the improvement of the Mississippi River are divided into two distinct parts: first, for deepening the channel, $3,159,200; second, for protective works, $4,000,000. If the purpose of Congress is to improve the navigation of the river and realize useful results at an early date, the distinction made in the estimates should be observed. The deepening of the channel precedes protection in order of execution and importance to navigation. Protective works have closer relation to individual and local interests, and are therefore more likely to be pressed upon the attention of Congress, in efforts to secure specific sums for specified localities; and it may not be out of place to suggest that private jobs are sometimes brought forward under the specious mask of public improvements. If Congress is disposed to accede to requests for the execution of these protective works in advance of their logical and natural order in the scheme of improvement, it should be with the understanding that all sums taken and made applicable to the protection of banks is so much deducted from the appropriation for the improvement of the navigation of the Mississippi River.

SURVEYS.

No extended surveys were made during the year. Special examinations were made at Piasa Island, Horsetail and Twin Hollow Bars, Liberty Island, and a resurvey from Dickey's Island to the mouth of the Ohio. The cost of these surveys was $4,799.90.

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The total expenditure for surveys since the organization of this office in 1870 has been:

Survey from Alton to mouth of Meramec River	$7,784 24
Survey at Cabaret Island	3,595 07
Board of engineers, convened by S. O. No. 20, H. Q. C. of E., February 7, 1872.	736 91
Survey from mouth of Missouri River to mouth of Ohio River	22,024 91
Triangulation from mouth of Missouri River to mouth of Ohio River	21,398 20
Special surveys, local	18,303 30
Total	73,842 63

Of which $48,008.77 was specially appropriated; the balance, $25,833.86, was borne by the general appropriation.

Of the above total $27,518.21 was expended by my predecessor, Lieut. Col. W. F. Raynolds.

EQUIPMENT.

As has been stated in previous reports, the interests of the work required that the Government should own a portion at least of the equipment needed to carry on the work.

The equipment now on hand is sufficient for the needs of the work, if continued upon the moderate scale of the past. A condensed statement of the property-account is given for information. It includes in the *Dr.* column the charter and operating expenses of steamers and barges; the *Cr.* column shows the value of the services rendered, and the *balance* column the amount with which the several classes of property are now charged upon the books of the office.

Class of property.	Dr.	Cr.	Balances.
Office furniture	$890 55	$390 00	$500 55
Instruments and survey material	4,791 80	3,941 80	850 00
Five pile-drivers	15,144 91	5,073 52	10,071 39
Eighteen barges and two quarter-boats	70,184 27	29,844 81	40,339 46
Tools	6,136 52	4,221 52	1,915 00
Quarters for workmen, shops, &c.	4,734 51	2,556 72	2,177 79
Two tow-boats and one steam-tug and expenses	130,177 98	73,775 14	56,402 84
Small boats	562 82	396 00	166 82
General expense of property	13,556 65	61 16	13,495 49
Material and quarry privileges	202,567 65	200,605 95	1,961 70
Total	448,747 66	320,866 62	127,881 04

Construction account.

Name of work.	Amount expended.	Amount required to complete.	Total.
Piasa Island dam	$16,210 73	$25,000 00	$41,210 73
Alton dam	31,368 45	8,631 55	40,000 00
Sawyer Bend protection	91,981 12	50,230 50	142,211 62
Long dike	36,341 85	3,658 15	40,000 00
Horsetail Bar, dike No. 1	26,873 83		
Horsetail Bar, dike No. 2	15,564 03		
Horsetail Bar, dike No. 3	47,506 80	72,510 98	221,502 86
Horsetail Bar, dike No. 4	38,648 17		
Horsetail Bar, dike No. 5	20,399 05		
Fort Chartres dam	36,887 86	9,750 00	46,637 86
Turkey Island dam	21,565 46	11,000 00	32,565 46
Liberty Island dam	5,053 91	*	5,053 91
Liberty Island protection	16,497 68	26,610 00	43,107 68
Devil's Island, dike No. 1	50,399 86		
Devil's Island, dam No. 1	43,084 06	47,036 90	150,000 00
Devil's Island, dam No. 2	9,479 18		
Total	507,862 04	254,428 08	762,290 12

* Will not be continued.

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DR. *Engineer Office, United States Army, in account with United States.* CR.

To allotments from appropriations for examinations and surveys on northern and northwestern lakes and rivers, and Atlantic and Pacific coasts, &c., made prior to 1872	$16,623 07	By expenses of office	$31,036 86
To allotment from appropriation for examinations and surveys and contingencies of rivers and harbors, approved June 10, 1872	21,385 70	By general engineering	19,945 52
To appropriation for improvement of Mississippi River from Illinois to Missouri, approved June 10, 1872	25,000 00	By surveys	73,842 63
To appropriation for improvement of Mississippi River from Missouri to Meramec, approved June 10, 1872	100,000 00	By construction	507,862 04
To appropriation for improvement of Mississippi River from Missouri to Ohio, approved March 3, 1873	200,000 00	By balances on account of property	127,881 04
To appropriation for improvement of Mississippi River from Ohio to Illinois, approved June 23, 1874	200,000 00	By cash on hand July 1, 1876	15,724 68
To allotment from appropriation for surveys and estimates for improvements on transportation-routes to the seaboard, approved June 23, 1874	10,000 00		
To appropriation for improvement of Mississippi River from Illinois to Ohio, approved March 3, 1875	200,000 00		
To unpaid percentage on annulled contracts	900 17		
To percentage due on existing contracts	2,133 38		
To amount due on non-p yment roll	250 45		
	776,292 77		776,292 77

The original estimates for the improvement of the Mississippi River between the Illinois and Ohio Rivers began with an estimate contained in the report of a Board of Engineers dated April 13, 1872, (Report of Chief of Engineers for 1872, page 366,) which was—

For erection of dike at Alton Harbor	$40,000 00
For protection of 2 miles of Sawyer Bend	142,211 62
For extension and raising of dikes in Northern Harbor of Saint Louis	197,323 90
For survey between Alton and the mouth of the Ohio River	30,000 00

Following this report, Congress appropriated, by act approved June 10, 1872—

For improvement of Mississippi River between the Illinois and Missouri	$25,000 00
For improvement of Mississippi River between the Missouri and Meramec	100,000 00

and ordered a survey of the river from the Missouri to the Ohio, for which there was allowed $22,584.79.

The above amount applicable to the section from the Illinois to the Missouri was applied to construction of the Alton Dam, and that applicable from the Missouri to the Meramec was applied to the protection of Sawyer Bend and extension of Long Dike.

The survey from the Missouri to the Ohio was made, and a preliminary report submitted under date of December 18, 1872. In that report estimates were given for—

Deepening the channel of the Mississippi River from the Missouri to the Ohio	$893,895 00
For securing the river in its present channel	2,102,149 00
Total	2,996,044 00

Following this report, an appropriation was made by act approved March 3, 1873—

For the improvement of the Mississippi River between the Missouri and Ohio	$200,000 00
And by act approved June 23, 1874	200,000 00

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By the act of June 23, 1874, a survey was ordered of the Mississippi transportation route, and there was allotted for the survey from the Illinois to the Ohio $10,000.

The report of this survey was made January 20, 1875, and is published in Report of Chief of Engineers for 1875, part 2, page 471.

In this report an estimate was given for—

Improving the channel between the mouths of the Illinois and Ohio Rivers.	$3,159,200
For revetments between the mouths of the Missouri and Ohio Rivers.....	4,000,000
Total.....	7,159,200

This last estimate covered the whole ground and includes the items of the preceding estimates which remained unprovided for at its date.

To arrive at the total estimated cost of improving the Mississippi River from the Illinois to the Ohio it is necessary to add to—

The estimate of 1875.....	$7,159,200
The sum of appropriations previously made.....	525,000
Making an aggregate of.....	7,684,200
Of which up to July 1, 1876, there has been appropriated.....	725,000
Leaving for further appropriations.....	6,959,200

A glance at these figures will show that at the rate of $200,000 per year, as for the last three years, thirty-five years will pass before the appropriations equal the estimates; the annual grant has been less than 3 per cent. of the total estimate, and 3 per cent. upon the original cost would be a very low figure for the maintenance of the completed work. It will be readily understood that with such small appropriations the completion of the improvement is postponed to an indefinite but distant future, for as progress is made the expense of maintaining the works will consume an increasing proportion of the annual appropriation, and eventually take it all. The estimates given were made with an allowance of but 10 per cent. for contingencies added to the cost of material. Examination of the construction accounts will show that the contingent items of cost vary from 5.2 per cent. to 29.9 per cent.; or taking a mean they are equal to $\frac{44,182.88}{463,679.16} = 0.09\frac{53}{100}$ per cent. The cost of administration is $\frac{31,036.86}{709,585.71} = 0.04\frac{37}{100}$; and the cost of general engineering is $\frac{19,945.52}{709,585.71} = 0.02\frac{81}{100}$. The two last items represent the cost of an engineer office and organization, the expense of which would not be perceptibly increased if the amount of business were much larger. The minimum ratio, 5.2 per cent, for contingencies of construction could easily be made the mean rate, if means were provided for a rapid execution of each individual work to completion. A large item in construction account is for transportation of material; the cost of transportation per unit depends in great measure on the quantity, as every business man well knows. Taking the aggregate of all the items into consideration, there can be no question but that $500,000 appropriated in one year will do as much work as $600,000 divided into three annual sums of $200,000 each. Last, year in estimating the amount required, $1,000,000 was given as the amount that could be profitably expended during the fiscal year ending June 30, 1877. The estimate for the year ending June 30, 1878, is for the least amount that can be profitably expended, $500,000.

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Money statement.

Balance in Treasury of United States July 1, 1875:		
On account of appropriation for improvement of Mississippi River, from the Illinois to the Ohio, approved March 3, 1875:		
For application between the Illinois and Ohio	$136,000 00	
For application between the Illinois and Missouri	15,000 00	
Amount in hands of officer and subject to his check, July 1, 1875:		
On account of appropriation for improvement of Mississippi River, from the Missouri to the Meramec, approved June 10, 1872	132 55	
On account of appropriation for improvement of Mississippi River, from the Ohio to the Illinois, approved June 23, 1874:		
For application between Ohio and Illinois	3,082 54	
For application between Missouri and Illinois	4,739 83	
On account of allotment from appropriation approved June 23, 1874, for surveys and estimates for the improvements recommended, by the Senate Committee on Transportation Routes to the Seaboard, &c., to be expended in the survey of that portion of the Mississippi route lying between the mouth of the Illinois River and the mouth of the Ohio River	382 50	
On account of appropriation for improvement of Mississippi River, from the Illinois to the Ohio, approved March 3, 1875:		
For application between Illinois and Ohio	49,000 00	
		$208,337 42
Amount expended during fiscal year ending June 30, 1876:		
On account of appropriation for improvement of Mississippi River, from the Missouri to the Meramec, approved June 10, 1872	132 55	
On account of appropriation for improvement of Mississippi River, from the Ohio to the Illinois, approved June 23, 1874:		
Between Ohio and Illinois	3,082 54	
Between Missouri and Illinois	4,739 83	
On account of allotment from appropriation approved June 23, 1874, for surveys and estimates for the improvements recommended by the Senate Committee on Transportation Routes to the Seaboard, &c., to be expended in the survey of that portion of the Mississippi route lying between the mouth of the Illinois River and the mouth of the Ohio River	382 50	
On account of appropriation for improvement of Mississippi River, from Illinois to the Ohio, approved March 3, 1875:		
Between Illinois and Ohio	172,958 08	
Between Illinois and Missouri	11,317 24	
		192,612 74
Amount available July 1, 1876, including $2,133.38 due on contracts:		
On account of appropriation for improvement of Mississippi River, from the Illinois to the Ohio, approved March 3, 1875:		
For application between Illinois and Ohio	12,041 92	
For application between Illinois and Missouri	3,682 76	
Amount appropriated by act approved August 14, 1876, for improvement of Mississippi River, between the Illinois and Ohio:		
For application between Illinois and Ohio Rivers	150,000 00	
For application between Illinois and Missouri Rivers	15,000 00	
For application between Islands No. 14 and No. 15, near the town of Kaskaskia, Ill	5,000 00	
For application between the foot of Dickey Island and the mouth of the Ohio River	30,000 00	
Amount appropriated by act approved August 14, 1876, for improvement of the channel of the Mississippi River, opposite the city of Saint Louis, Mo., by the construction of a low dam across the channel east of Arsenal Island, known as Cahokia Chute, and in the revetment of said island	29,600 00	
		245,324 68
Amount (estimated) required for completion of existing project		6,729,600 00
Amount required for fiscal year ending June 30, 1878		500,000 00

The collection-district in which the work is located is New Orleans.

Amount of revenue collected at the port of Saint Louis for the fiscal year ending June 30, 1876, was $1,592,407.09.

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Abstract of contracts for improvement of Mississippi River between the Illinois and Ohio Rivers, let under the appropriation approved March 3, 1875, agreeably to proposals opened June 29, 1875.

Name of contractor.	Date of contract.	Section.	Character and price of material, &c.													
			Pile-timber.	Piles driven 10 feet—Government furnishing machinery.	Piles driven 10 feet—contractor furnishing machinery.	Piles driven in excess of 10 feet—Government furnishing machinery.	Piles driven in excess of 10 feet—contractor furnishing machinery.	Brush.	Stone for riprap from Government quarry.	Stone for riprap from private quarry.	Spalls.	Gravel.	Sand, loam, or clay excavation.	Transportation of material, unit 1 yard, 100 feet.	Common labor of men.	Common labor of teams.
			Per foot.	Per pile.		Per foot.		Per cord.	Per cubic yard.					Per yd., 100 ft.	Per hour.	
Henry Doering	July 15, 1875	First section	$0 03	$2 50	$3 00	$0 01	$0 02	$1 50	.....	$1 17	$0 20	$0 50	$0 10	$0 01	$0 22½	$0 25
Do	July 15, 1875	Second section	03	2 50	3 00	01	02	1 50	$1 15	1 22	30	50	10	01	20	30
George Williams	July 15, 1875	Third section	05½	1 00	1 00	03	03	1 60	75	80	30	20	.....	.....	.....	.....
Do	July 15, 1875	Fourth section	06	1 00	1 00	03	03	1 75	85	90	35	20	.....	.....	.....	.....

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M 2.

IMPROVEMENT OF OSAGE RIVER, MISSOURI.

The funds being exhausted, and Congress making no provision for further work, no operations were carried on for the improvement of the Osage River during the year.

Under authority from the Chief of Engineers, and agreeably to advertisement, the floating and other property pertaining to the improvement was sold at public auction on the 1st of July, 1875, the proceeds of the same, less expenses of sale, being turned into the Treasury of the United States.

M 3.

SURVEY OF THE MISSISSIPPI RIVER, NEAR KASKASKIA, ILL.

ENGINEER OFFICE UNITED STATES ARMY,
Saint Louis, Mo., April 28, 1876.

GENERAL: I send herewith a tracing of the recent survey, near Kaskaskia, Ill., which was made at the request of Hon. William Hartzell. The tracing shows the late survey in black lines, and the surveys of 1873 and 1874 are shown in blue.

The request for this survey was based upon an apprehension that the rapid erosion would at an early date result in the junction of the Mississippi and Kaskaskia. The survey was made by Assistant Engineer Charles S. True, from whose report I extract the following description:

The shortest distance between the two rivers is above the upper landing, and opposite the western bend of the Kaskaskia River. This distance on the 16th of March was 2,080 feet, and on the 18th of March but 2,040 feet. The greatest erosion of the bank has occurred in this part of the bend, and has been about 650 feet in nineteen months. In the lower part of the bend the bank has caved but little. At the lower landing, Mr. Stone's warehouse has been moved once since the survey of August, 1874. The blocks that supported the rear of the warehouse in its former position still remain in place, and measurements show the distance the warehouse has been moved to be 74 feet. The rate of erosion of the bank is irregular. During the northwest gale of the 16th and 17th of March, the bank opposite the upper cross-line caved back 40 feet, and farther down stream the caving was still greater. These, however, were extreme days. Mr. Chaunte's warehouse at the upper landing was moved back from the river on the 15th of March, and he was compelled to move it again on the 18th, to prevent its being carried away by the river.

While the Mississippi has advanced towards the Kaskaskia 650 feet in 19 months, it has made the greater part of that advance since the 1st of July, 1875.

General Warren's map, made in 1867, shows the distance between the Mississippi and Kaskaskia Rivers, where it is now least, to have been fully 1¼ miles. I do not know the date when the Mississippi was as shown on General Warren's map, though it was probably some time prior to the date of the map. The part of the Kaskaskia surveyed this spring is nearly the same now as then; therefore the change is due almost wholly to the Mississippi. General Warren's map shows a broad stream of water passing to the eastward of Ste. Genevieve Island, which made the river more direct than now, and the current must have been more nearly parallel with the Illinois shore.

The present shape of Ste. Genevieve Bend causes the water to flow north of east, and impinge strongly against the Illinois shore, where the Mississippi is nearest the Kaskaskia. For these reasons this part of the Mississippi is likely to advance toward the east faster in the future than it has in the past, and it will probably be but a few years before the Kaskaskia will join the Mississippi in this bend. There is one condition under which this will not occur. Should the Mississippi cut away the point at the foot of Ste. Genevieve Bend, so that the current of water will reach the Illinois shore lower down, then the bend in the Mississippi will follow its natural tendency to move down stream and pass below the bend in the Kaskaskia River without cutting it. It is more probable, however, that the wear of the point at Ste. Genevieve Bend will be too slow to prevent a junction of the two rivers.

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What the consequence of a junction of the river in Kaskaskia Bend may be, cannot be foretold with certainty. It is my opinion that by the time it will occur the main bend of the Mississippi will have moved so far down that in the low-water season the part of the Kaskaskia River below the junction will be but an island slough. The Kaskaskia has a clean, well-shaped channel from 500 to 600 feet in width, and excepting the big bend at the upper ferry is quite direct in its course to its mouth. From Kaskaskia Bend to Chester, by the Mississippi River, the distance is 15½ miles, while by the Kaskaskia River, as laid down on General Warren's map, it is bnt 10⅝ miles. At a high stage of water the cut-off of the Kaskaskia might be so deepened as to become the main channel. At a stage of the Mississippi 20 feet above low water, the cross-section of the Kaskaskia below the junction would be not less than 5,000 square feet, and the discharge between 20,000 and 30,000 cubic feet per second. The discharge of the Mississippi at that stage is about 300,000 cubic feet per second, and the cut-off would have so small a part of this that it might fill rather than deepen. This uncertainty of channels is well illustrated by comparing the river as shown on General Warren's map with its condition at the present time. On the map a broad channel is shown to the eastward of Ste. Genevieve Island. The main body of the river still crosses from the lime-kiln, above Little Rock, to the Illinois shore at the head of the island, and the eastern side of the island seems the most direct and probable place for the channel, but instead of being kept open by the river it has been filled with sand and the water goes round by the less direct bend. The channel to the eastward of Grand Tower Island, when General Warren's map was made, was a narrow slough, and I have been told by steamboat-men that that was its condition but a few years ago. The river has abandoned the direct channel to the eastward of Grand Tower Island for its low-water work, and has changed the crooked narrow slough to the main channel.

Should the Mississippi cut through to the Kaskaskia and fill the lower part of the latter river with sand, it would have no injurious effect on commerce; nor would it necessarily have a bad effect should the Kaskaskia cut-off become the main channel, but a division of the river would be decidedly injurious to navigation. To prevent a division of the river a low dam could be built across the Kaskaskia below the junction, and if done before any great amount of cutting of the banks occurred, its probable cost would not exceed $35,000. To prevent the cut-off being made, a shore protection of stone riprap can be placed in the bend. This protection would need be 6,000 feet in length, and to have 5 cubic yards of stone per linear foot, or 30,000 cubic yards of stone, which, at $1.40 per cubic yard, would cost $42,000. A shorter or lighter wall would be liable to be flanked or cut through by the river and become an obstruction to navigation.

The revetment of Kaskaskia Bend is not imperatively demanded by the present needs of navigation, but as a preventive of future bad results a protection of the bank may be a good investment.

Another argument for a revetment at the present time is, that it would probably preserve a better condition of the channel and currents in the river below it, and so help in any future work that may be required in the neighborhood of Kaskaskia and Saline Islands. By reference to the map it will be seen that the channel which has for several years so persistently run up against the foot of Fairy Island, has lately changed lower down and goes direct to the rock bluff below the Rivière Aux Vasses. This channel is now deep and direct, and promises to be the low-water channel for the present year. Anything that helps regulate the currents above will be beneficial to this part of the river.

Agreeing with Mr. True in his opinion that the probable results in case of a junction will not seriously injure navigation, I do not think that a protection of this locality is demanded now as an improvement of the navigation, although the protection of such bends, and prevention of changes, such as is apprehended here, would necessarily follow the improvement of the channel in the vicinity, as a work of maintenance. Should any consideration be given to the preservation of valuable land, then the matter would become one of pressing importance, as several thousand acres of the most productive land in the country are in danger; but in the absence of any authority for the consideration of such interests, I am not at liberty to recommend an appropriation for the protection of this locality at present.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

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M 4.

SURVEY OF THE MISSISSIPPI RIVER IN THE VICINITY OF CAIRO.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., February 5, 1876.

GENERAL: I have the honor to forward herewith a tracing of a comparative map of the Mississippi River in the vicinity of Cairo, showing the changes during the interval between July, 1874, and November, 1875.

The shore-lines in black are those given by the survey made in November, 1875; those shown in yellow are from careful topographical sketches made at the time the triangulation was made in July, 1874. The rapid erosion of the Illinois shore opposite Eliza Towhead has caused great alarm to the citizens of Cairo, and fear that the Mississippi may continue to work its way toward a junction with the Ohio above the city, and leave the city on an island, both sides of which will be exposed to the action of the currents; or, if not, that the bend will approach the Ohio at a lower point, and in that case endanger the site of the city. They, consequently, as I have been informed, propose to apply to Congress for an appropriation for the protection of the caving bank from near the foot of Dickey's Island to the spur-dikes opposite the town. In anticipation of such application, the survey of November, 1875, was made in order that the necessary information might be in readiness when required to enable Congress to pass upon the propriety of affording the relief asked for.

In order to fairly represent the approximation of the Mississippi toward a junction with the Ohio above the city, the shore-lines of the Ohio River have been carefully transferred from a map published in the Coast-Survey Report for 1864, (which is the best authority in possession of this office,) and which is presumed to be substantially correct, as the banks of the Ohio are judged to be stable, and have changed but slightly, if at all, since the date of the survey used as authority.

The minimum distance between the two rivers is thus shown to be nearly 4,000 feet now, whereas it was, in July, 1874, 4,175 feet, a decrease of 175 feet during an interval of fifteen months. The point of least distance between the rivers does not coincide with the locality where the greatest erosion has occurred. According to the usual tendency of physical changes to progress down-stream, it is reasonable to expect that the locality of greatest erosion the coming season will more nearly coincide with the point of least distance between the two rivers. Should this be the case, with the rate of maximum erosion in the past as an index to the future, the distance between the two rivers is likely to be reduced the coming season to about 3,500 feet. By scale-measurement on the Coast-Survey map of 1864, the distance between the two rivers was then 4,888 feet, and a map made in the office of the Cairo and Saint Louis Railroad makes the same distance 4,800 feet. The later map was made after the location of the railroad, which was made in the autumn of 1871, by Mr. S. E. McGregory, who is now an assistant in this office, and bears testimony that at that time the current did not set against the bank of the river, a statement which must be correct, as the road was finally built quite close to the river-bank, which certainly would not have been done if the bank had been caving at that time. These facts confirm the older maps in their testimony that the changes were slight between 1864 and 1871. The waste between 1871 (and probably a considerably later date) and July, 1874, must have been about 625

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feet. The changes during the last few years have therefore been rapid, and by applying the rate it would be easy to calculate the comparatively short period required to establish the junction of the two rivers above the city.

All such calculations are deceptive, as erosions in any particular locality or in any particular direction are known to increase to a maximum and then decrease to a practical zero.

The apex of the bend will move down-stream, and the point of maximum erosion travels with it. I therefore incline to the opinion that the apprehension of a junction of the rivers above the city is unfounded, as also that as to the present town-site being endangered at any date within prevision now. At the same time there can be no question but that a large part of the vacant ground in the rear of the town will be cut away in the early future, unless the river changes the course of its strongest current, which there is no apparent reason to expect.

At the lower end of the bend, as it now exists, a series of spur-dikes are found which were built by the Cairo Land Company in the period between 1858 and 1868, to check a then threatening erosion; these dikes doubtless served the purpose of their construction, but under the new conditions are themselves exposed to an attack in flank to which they present no sufficient resistance. One of the series at A on map has already been detached from the bank, and the rock of which it was built now lies in mid-channel, forming a dangerous obstruction and also aiding the river in the destruction of the next of the series by directing upon its flank the rapid current which passes between its remains and the shore. This second spur is already in a precarious situation, and will probably before spring be detached, when it will form a second dangerous obstruction, and in its turn hasten the destruction of the next of the series, and thus finally all will be detached.

In my judgment it is very important that these dikes be preserved, as they would serve as an efficient protection to the front they cover if themselves protected from flank attack by works above. In my report upon "Part of the third subdivision of Mississippi transportation route," (see Appendix CC 4, Report of Chief of Engineers, 1875, second part, page 492,) I said:

> To maintain that navigation will require the revetment or other protection of caving banks. The estimated sum of $4,000,000 is intended to cover the cost of such works to preserve the channel at those points where the necessity is likely to occur.
>
> Further examination would be necessary to determine where works of this character are most needed. The greater part, we may safely say, would be required between Commerce and the Ohio.

The bend now under consideration, and also the succeeding one on the Missouri shore nearer the mouth of the Ohio, also shown on the map as the scene of very active erosion, were in mind when that report was prepared as probably the first localities where protective works of serious extent would be required, and, in my judgment, the necessity for protective works at both these localities is immediate, in the interest of an improved navigation; because the position, shape, and depth of channel, throughout the part of the river shown on this map, are now favorable, and could be rendered permanent with as little cost as will ever be possible in the future, and conditions equally favorable may not occur again if the work be deferred; moreover, delay will assuredly result in transforming the spur-dikes already mentioned from beneficial structures to dangers similar to the noted Bacon Rock lately removed under the authority of Congress, after having caused many disasters to boats.

Passing to the consideration of the plans proposed for the protection

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of these banks, three several systems are suggested as probably effective. The first is a suggestion made by persons living at Cairo, and contemplates the construction of a dike extending from the Illinois shore, near the upper limit of the map, so as to force the channel to the right of Eliza Towhead. This is objectionable on the ground that it involves a radical change, which cannot be secured by any single dike, for the reason that single dikes perpendicular (or approximately so) to the current have no determinate effect; the employment of such dikes is legitimate only in *systems*, and a series of dikes sufficient to insure the result proposed would be very expensive in this locality. The second plan is to protect the caving bank by a series of short spur-dikes; and the third is to do the same by a continuous revetment. The experience gained from the work at Sawyer Bend, above Saint Louis, constructed under this Office, affords the means of comparing the merits of these two methods of bank-protection. Both having been tested, and both being successful, the choice may properly be left to consideration of cost of construction and repair, so far as the portion of the bank above the ordinary mean stage of the river is concerned. Below the level of the mean stage no dependence is to be placed upon any work which is not continuous.

In Sawyer Bend, both revetment and spur-dike rest upon a heavy longitudinal wall of riprap, founded in a trench at least 8 feet below low water and extending 5½ feet above extreme low water, or about to the level of mean low water of navigable seasons. Although these works have stood satisfactorily, it would not be justifiable to duplicate them in the light of present experience, since a cheaper and equally efficient mode of construction has been devised, and practically tested, which can be applied to cases such as we meet in the vicinity of Cairo, where the depth is too great to admit of the use of piles, and the construction of the heavy longitudinal wall which, with its trench, has consumed the greater part of the cost of the Sawyer Bend work.

The method now pursued, and which is recommended for use at Cairo, is to use continuous rafts of brush, formed in place, and extended down stream as work progresses; these rafts to be moored so as to hold the inner side close against the bank, and in that position to be loaded with riprap, the loading to progress down stream and from the bank outward, so as to firmly anchor the inner side upon the slope of the bank, and avail ourselves of the tenacity of the raft to carry the increasing load of riprap gradually, and without breach of continuity, to its final resting-place on the sloping bottom. Where the depth is considerable, these rafts must be proportionally widened to reach from the foot of the steep part of the bank well out on the under-water slope.

In this connection it is well to state that, however steep the visible part of the bank may be below ordinary low water, the banks of the Mississippi, between the Missouri and the Ohio, almost invariably present a well-defined declivity, varying from 1 to 2 horizontal to 1 perpendicular within the breadth of a raft of ordinary dimensions; more strictly, the declivity is a curve, approaching the horizontal as we recede from the bank.

Protection of this character extending only to the level of the mean stage is not claimed to prevent the erosion of the upper part of the bank at first, but is designedly left at that point in order that a further abrasion may take place above that level, in the confident expectation that, the foundation remaining secure, only surface-currents will act on the exposed bank, and the result will be a prolongation of the lower

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slope, which will ultimately assume a form of stability, either with or without artificial assistance.

The length of bank whose protection is necessary, immediately above Cairo, is 11,500 feet, which, at an estimated cost of $15 per foot, would cost $172,500; on the Missouri side, near the mouth of Ohio, 21,700 feet, at $15 per foot, would cost $325,500; total, $497,500, of which $200,000 could profitably be expended during the season of 1876.

Works of protection and maintenance having been separately estimated in the report on transportation-routes from works for improvement of the navigation, the estimates here given, being for protection, are to be taken from the $4,000,000 item of the estimate. The estimate of funds required, specified in my annual report, dated July 12, 1875, having been for improvement works, the present estimate is not properly provided for in the annual report.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX N.

ANNUAL REPORT OF COLONEL J. N. MACOMB, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 12, 1876.

GENERAL: I have the honor to submit herewith the annual reports upon the several works in my charge during the fiscal year ending on the 30th June, 1876, together with the estimates for continuation or maintenance of said works for the fiscal year ending 30th June, 1878.

I remain, very respectfully, your most obedient servant,

J. N. MACOMB,
Colonel of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers.

N 1.

IMPROVING UPPER MISSISSIPPI RIVER.

The usual work of the season done by the use of the United States steamer Montana, provided with one of Long's scrapers, was conducted as heretofore by Capt. J. B. Davis, whose report is herewith submitted, by which it appears that important aid was rendered to the navigation, and that a steamer equipped after the fashion of the Montana is essential to keeping open the navigation of the Upper Mississippi River on the approach of the low-water stage in July, and during its continuance until the close of the season. It is, therefore, with confidence that I ask for an appropriation for this work, for the coming season, large

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enough to procure a new hull for receiving the machinery now in use upon the Montana, and, from my experience and observation upon the lakes, as well as upon the western rivers, I am of the opinion that it would be true economy to have an iron hull for this service.

From Captain Davis's report, it would evidently be false economy to continue the Montana in use after the present season on account of the large outlay that would be necessary for repairs.

ESTIMATE.

For new iron hull, including iron deck, deck frame, boiler-deck stanchions, and engine timbers	$55,000 00
For three steel boilers complete	5,000 00
For cabin, sheet-iron wheel-houses, and other upper work	5,000 00
For transferring and setting up machinery, &c., in new boat	1,500 00
	66,500 00
For current expense of boat and working party, for fiscal year ending June 30, 1878	25,000 00
Total	91,500 00

Money statement.

Amount available July 1, 1875	$23,539 49
Amount expended during fiscal year ending June 30, 1876	21,929 63
Amount available July 1, 1876	1,609 00
Amount appropriated by act approved August 14, 1876	30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	91,500 00

REPORT OF CAPTAIN JOHN B. DAVIS.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., June 30, 1876.

SIR: I have the honor to submit herewith my report on the operations of the United States steamer Montana, in improving the Upper Mississippi River during the working season of 1875.

The Montana left Rock Island on the 7th of July for Saint Paul, with the United States quarter-boat Maj. E. F. Hoffmann in tow, and with instructions to render assistance to Assistant Engineer C. W. Durham and party, who were engaged in surveying some of the obstructed portions of the upper river. Arrived at Saint Paul on the 12th of July, where we remained until the 14th, during which time the surveying party were engaged in making an examination of Pig's Eye Bar, and observing the effect upon the channel caused by the dam built by the Montana, in 1874.

On the 14th of July the Montana again took the quarter-boat in tow, and remained in company until the 27th, working in the vicinity, while the surveying party made surveys at Brownsville, Cassville Slough, Specht's Ferry, Dead Man's Bar, Bellevue, Lyons, Horse Island, and Keithsburgh. On the 27th of July, leaving the quarter-boat at Keithsburgh, the Montana returned to Rock Island, and, taking you on board, proceeded to Montrose, Iowa, for the purpose of making an inspection of the United States works of improvement at Des Moines Rapids in your charge. Left Montrose on the 31st, and proceeded up river, removing all snags, stumps, and leaning trees on our way. Arrived at Pine Bend on August 12, and found only 2½ feet of water on the bar; ran down to Beef Slough, dredged the bar at that point, and then proceeded to La Crosse Slough, and cleared the slough of obstructions on the 18th, the channel having changed to the eastern side of Minnesota Island; ran down to Bellevue, and spent ten days dredging at Bellevue and Sand Prairie Bars.

Having learned that there was a dangerous stump in the channel at the head of Cassville Slough, which had injured and nearly sunk the steamer Minneapolis, we ran up to that point and removed it; the river having risen several feet, we then proceeded to Boulanger's Bar above Hastings, and commenced building a dam according to your directions on the 9th September. Worked at Boulanger's until 1st of October, at which time the dam was completed, it being 460 feet in length. This dam increased the depth of water in the main channel fully 18 inches.

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Commenced work at Pig's Eye October 4, in strengthening the dam at that point and in riprapping the western shore opposite the head of Pig's Eye Island, which work was completed on November 2.

The result of this dam has been an increase of 18 inches depth of water on Pig's Eye Bar, so that this bar which was formerly the worst obstruction to navigation in the upper river, and which caused boats to turn back when only 5 miles from Saint Paul, is now permanently improved, and it is thought that there will always be sufficient water on this bar for boats which have been able to come up to it from below.

Left Saint Paul November 4, and ran down to Coon Slough, 17 miles below La Crosse, and dug a ditch to straighten the channel, excavating 1,116 cubic yards of earth; ran down to Rock Island, arriving on November 15. On the 16th, ran down to a point a short distance below Buffalo, Iowa, and removed a large bowlder from the channel; by your directions ran down to Port Louisa and removed two large trees that were in the bend of the river, and also one snag at Muscatine Island; laid up at Rock Island November 20, barely in time to escape the ice.

The following is a summary of the work performed during the working season by the steamer Montana in the fiscal year ending June 30, 1876:

SUMMARY.

12 steamers pulled off sand-bars; 1 raft pulled off sand-bars; 4 barges pulled off sand-bars; 1 wharf-boat pulled off shore; 38 snags extracted; 9 stumps extracted; 169 leaning trees removed; 18 channel-marks placed, (shore marks for ranges;) 11 buoys placed to mark channel; 14 days dredging bars; 2 bowlders removed; 1,116 cubic yards earth excavated; 10 barge-loads stone put on Pig's Eye Dam; 7 barge-loads stone put on Pig's Eye Riprap; 16 barge-loads stone put on Boulanger's Dam.

Three thousand five hundred and thirty-five miles run in prosecution of the above work.

I would respectfully call your attention to the fact that the work of building dams at Pig's Eye and Boulanger's has been done at times when the water was at such a stage that the Montana could be spared from her other duties of dredging, removing snags, and assisting steamers, and with the small crew at our command and the small appropriation ($25,000) the work was necessarily slow, requiring three seasons to accomplish the desired result.

You are also aware that a great deal of experimental work has been done under your directions, in order to ascertain what kind of dams would be the most efficient and permanent. As these dams above mentioned are the first that have been constructed on the Upper Mississippi River, and have produced the desired result, viz, 4½ feet at the lowest stage of water, it only remains to be seen whether they will be *permanent* in order to proclaim their complete success. I would further state that the steamboat-owners, steamboat-men, and lumbermen are all highly pleased with your plan of improving the river, and hope that Congress will make an appropriation sufficient to enable you to continue the good work next season.

The steamer Montana is now twelve years old. With an outlay for repairs of about $1,500 she can run during the working season of 1876, but it will require a very heavy repair account after this season to keep her in a seaworthy condition, and the expense will increase yearly as she grows older. Her machinery is excellent and could be used to good advantage in a new boat.

The boilers would not be suitable to transfer to another hull, and consequently I would respectfully recommend new steel boilers for a new steamer. In my opinion an iron hull to receive the Montana's machinery should be of the following dimensions, viz: Length on deck, 190 feet; breadth of beam, 37 feet; depth of hold, 5½ feet. Model full, with transom stern.

An iron hull of these dimensions with the Montana's machinery and a small cabin for the officers should not exceed 24 inches draught when completed.

The draught of the Montana is now 3 feet 3 inches, which is entirely too much for effective work in low water on the Upper Mississippi River.

Taking into consideration the age of the Montana, her heavy draught, and the large amount it will take yearly for repairs, in my opinion it would be true economy and to the interest of the Government to build an iron-hull steamer to take the Montana's place by next season.

All of which is respectfully submitted.

I remain, very respectfully, your most obedient servant,

JOHN B. DAVIS.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

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N 2.

IMPROVING DES MOINES RAPIDS, MISSISSIPPI RIVER.

This work has continued in the immediate care of Capt. Amos Stickney, Corps of Engineers, and has been ably managed by him. I beg leave to refer to his report herewith presented for detailed information as to the progress of the improvement.

The work of laying riprap face on the banks of the canal has been prosecuted energetically, the stone for that purpose being purchased on advantageous terms in open market. The inside face of the canal-embankment, between the guard-lock and middle lock, is now nearly completed, and all but one of the creeks and small streams empyting into this level have been curbed with permanent loose stone dams, and silt-pools formed so as to prevent the canal from being encumbered with débris from these sources.

Much work was done during the year in excavating the prism of the canal, and it was found to be a much more expensive undertaking than had been anticipated. The creek-openings not having been protected by the contractors at work in former years, large quantities of mud and other material had been washed into the canal, requiring a great deal of labor for its removal, even at points where the excavation had been finished. The work went on, however, for some time satisfactorily, until the floods of September filling the canal compelled a temporary suspension.

Captain Stickney estimates the damage done by these floods at $20,000. On the subsidence of the water, work was again resumed, and at present writing but very little labor is required for finishing this part of the improvement.

Considerable trouble was experienced in stopping the leaks under the canal-banks, but this was at length accomplished.

For excavating a channel through Montrose Chain, to perfect the navigation to deep water above the guard-lock, a large coffer-dam was constructed, 5,782 feet in length and including 95 acres of river. This was a work of great magnitude and risk, and was pushed to completion on the 24th of August, at which time it was pumped dry and the bottom laid bare. The work of excavation was immediately begun and pushed forward as rapidly as possible, but on the 3d of September, owing to a crevice in the bed-rock, a leak sprung which undermined the walls and flooded the dam.

The dam was repaired, and work was resumed on the 8th of September. On this day there was an unprecedented rise in the river, which, in spite of every effort, caused a break in the dam, some 600 feet of which was carried away. Owing to the continuance of high water in the river, repairs on the dam were not completed until the 12th October, at which time a force of 900 men was put on the work, which was carried on until the 2d January, 1876, when the dam was overwhelmed and carried away by another terrible flood. Notwithstanding these misfortunes, involving great expense and causing a diversion of funds intended for other portions of the improvement to this work, the dam was again rebuilt, and work resumed on February 7 and continued until February 24, when the appropriations were exhausted. At this time the excavation of the channel was completed, with the exception of a small patch of rock near the head of the dam. In spite of the numerous disasters experienced, the cost per cubic yard of rock excavated was only about one-half the usual price of similar work done by contract.

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Another smaller dam was built below the Montrose Dam, from which 8,469 cubic yards of rock were taken.

Three chisel-boats were employed during a portion of the year in removing various patches of rock above the Montrose dam.

During the year work upon the guard-lock has been carried on nearly to completion, the remainder of the stone being on hand, cut ready for use, and had the appropriation not been exhausted, this lock would have been ready for navigation during the low-water season of 1876.

Owing to the failure of the contractors to deliver the lumber in season, work upon the lock-gates was much delayed. The gates of the upper and lower locks are, however, nearly completed, and the labor yet to be done is principally putting up the gates and fitting the iron-work to them.

The hydraulic machinery designed for operating the lock-gates is nearly finished, and has been constructed, under the immediate supervision of Captain Stickney, by Sample, McElroy & Co., of Keokuk, Iowa. A great portion of this machinery has been delivered or is ready for delivery, and some of it has been placed in position. For a full description of the machinery and the engine-houses designed for its reception, one of which is already built, I beg to refer you to Captain Stickney's report.

The amount required for the maintenance of the work during the fiscal year ending June 30, 1878, is $40,000, an appropriation of which amount is respectfully recommended.

Money statement.

Amount available July 1, 1875	$582, 889 88
Amount expended during fiscal year ending June 30, 1876	582, 889 88
Amount appropriated by act approved August 14, 1876	230, 000 00
Amount (estimated) required for completion of existing project	95, 000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878, including amount for annual maintenance	135, 000 00

REPORT OF CAPT. AMOS STICKNEY, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, June 30, 1876.

COLONEL: I have the honor to make the following report of the operations on the work of the improvement of the Des Moines Rapids of the Mississippi River for the fiscal year ending June 30, 1876.

On the 1st of July, 1875, there remained on hand from last year's appropriation $101,889.88. The amount appropriated by act of Congress approved March 3, 1875, was $480,000. The project for carrying on the work during the year, in addition to work previously projected, was as follows:

Excavation of channel through Montrose chain and patches.

Construction of gates in locks and sluices together with machinery.

Procuring stone and building face of riprap-wall on embankment.

Finishing up prism of canal.

Work was carried on under all of these heads until the latter part of February, when it became necessary to stop every thing on account of the exhaustion of the appropriations. The survey of the upper part of the rapids made last summer developed the fact that the estimates of rock excavation through Montrose Chain and patches, made from the survey of 1867, were too small by 25,200 yards, and during the progress of our work on Montrose Chain and patches in the past year the necessities of the case required me to use upon it and divert from other parts of the improvement a considerable amount of the money that had been allotted to them, and thus those other parts which I had intended to complete are still in an unfinished condition. In addition to the increase in the amount of rock excavation, we have had a most miserable season for our work, the great quantity of rain and the many floods of the river have kept us

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in a constant state of anxiety and have added very materially to the cost of almost every part of the work, so that it became necessary to increase the amount asked for the completion of the work. There has been very great satisfaction during the year in the manner of doing the work, that is, by hired labor, notwithstanding the fact that the labor in my office has been very greatly increased thereby. Every thing has worked smoothly under this system, the work is better done and costs less, yet laborers receive more; and we can rest with the calm assurance that no contractor's claims can arise.

The following is a detailed statement of the work on the various parts of the improvement.

SECTION WORK.

The beginning of July, 1875, found this portion of the improvement being pushed forward as energetically as the continued and excessive rains which had flooded most of the work would allow, and on account of the frequent floodings the quarrying of stone for riprap-wall from the prism of canal having become too expensive, it was decided to depend upon the market for purchasing all such stone.

The quarry gangs were consequently transferred to the other portions of the work.

LAYING RIP-RAP FACE ON THE BANKS OF THE CANAL.

A large quantity of stone was purchased in open market, and as many men kept on the wall as could work to advantage, laying up not only the purchased stone, but such as had already been placed on the banks for that purpose, during previous years, with the following result:

From the guard-lock to the middle-lock, a distance of about 5 miles, the inside face of the canal embankment is now built up to high-water mark in the canal, with the exception of a small gap, and nearly all (except about 500 feet) of the shore bank is protected in the same manner where required. All but one of the creeks and small streams emptying into this upper level have been curbed by permanent loose stone dams built across the mouths, thereby forming silt pools that effectually prevent the *débris* from the streams being washed into the channel. The inside face of the embankment through the lower level, about 2¼ miles in length is generally protected by a wall 4 feet and over above grade, although for some distance (3,000 feet) it is only about 2 feet above grade.

The small streams of which there are three, emptying into this level, have not as yet been guarded.

This makes 9,200 lineal feet of embankment, and 5,300 lineal feet of shore bank in the upper level thoroughly protected and finished to the 8 feet or high-water line this year, which with what has previously been done, places that portion of the prism in a condition to receive water for navigation.

And 9,600 lineal feet of embankment in the lower level upon which wall has been laid, although 3,000 feet is but 2 feet above grade, the balance being 4 feet and over. This will soon admit of water being let into the level, and stone for riprap delivered by means of boats.

FINISHING PRISM OF CANAL.

This has been found a much more expensive undertaking than was anticipated Owing to irregular and incomplete appropriations, some of the previous contracts had been stopped prematurely, and large quantities of material scattered over considerable space, necessarily remained in the canal.

The openings from the creeks had never been properly protected until the present season, and in consequence, the *débris* from frequent and heavy floods had again partially filled the prism, even where the excavation had been completed. Most of this material was soft mud, and difficult to remove. There were also numerous bowlders where the natural bottom of the river had been enclosed in the embankment, stumps of trees, old logs, and guard or cross banks which had been built to facilitate the excavation, all of which had to be removed.

The work went on satisfactorily until the floods of September, 1875, came, and filled the whole canal with water; all the creeks were bank full; the river rose rapidly, and backing up into the lower level, caused a suspension of work for some time.

During the flood a great deal of damage (besides the delay which in itself was a very serious damage) was done, and it together with the unprecedented floods about New Year's day of 1876, are estimated to have increased the cost of this portion some $20,000. However, as the men were thoroughly organized and were skilled, the work was pushed as rapidly as possible until the exhaustion of the appropriation required it to be stopped. The operations under this head during the year give the following results: The upper level between the guard and middle locks, with the exception of removal of one guard-bank a mile below the guard-lock, is entirely finished and ready for water. The

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lower level between the middle and lower locks requires some little excavation just below the middle lock and the removal of the guard-bank at the head of the lower lock

STOPPING LEAKS UNDER CANAL BANKS.

This work, although like all the rest during the last fiscal year much delayed and increased in cost by the disastrous floods of the fall and winter, was finished satisfactorily.

Work had been resumed in June, 1875, upon the large leak under the bank one-half mile below the middle lock. It was found to be very much larger than had been anticipated. The success met with in endeavoring to close the other leaks having been so marked, it was hoped there would be but little trouble with this, but it was found decidedly otherwise.

The crevice in the bed-rock of the river through which thousands of gallons of water poured into the canal, was from 2 to 4 feet below grade, and in order to get at it, about half of the embankment for a length of 500 feet had to be removed, and the rock excavated under water, which was tedious and expensive. After the crevice had been thoroughly exposed the trench was mostly filled with concrete, and a puddle-wall carried along through the bank, which almost completely stopped the leak.

The bank has since been rebuilt and the bottom of the slope protected by a well built riprap-wall about 4 feet above grade.

MONTROSE DAM.

The water having subsided sufficiently after the June freshet, work upon the large coffer around the upper or Montrose Chain was carried on vigorously, and about August 13, 1875, the dam was closed and pumping commenced.

The projecting and energetic pushing of this large dam to completion, 5,782 feet in length, and inclosing 95 acres of the waters of the Mississippi, has been a work of considerable magnitude and great risk. By the 24th of August, the water having been pumped out, the excavation of rock in the channel was commenced. Men were placed upon the work as rapidly as they could be obtained. Rock was being excavated and placed in "spoil bank" up to the 3d of September, when, owing to a crevice in the bed-rock, a leak sprung near the engine and pump at the lower end of the dam, a portion of the walls were undermined, and, being unable to withstand the weight of the impending water, were crushed, and in less than 40 minutes the dam was flooded. This was merely a premonition of the many and disastrous accidents it was doomed to suffer. Next day repairs were commenced; on the 8th of September the dam was again pumped and work resumed. On that day an unusually heavy rain-storm occurred, which raised all the small streams throughout this section of country. The Mississippi, in conjunction with the other rivers, rose to the height of the spring floods. The dam being greatly threatened, it became necessary to cut it and let it fill, and again the work was stopped. This, however, was justifiable, for in a day or two the whole dam was nearly submerged, and on account of the difference of level at the head and foot the strong current soon cut through the filling of the walls of the coffers and about 600 feet of the dam was carried away, making a cross-current that caused a heavy log-raft to float in and unship the engine and pump at the lower end and drop them into the river, which, together with the loss of a number of small tools and material of various kinds, was quite a serious misfortune.

As the flood had subsided sufficiently by the 23d of September, repairs were inaugurated and pushed as rapidly as possible; the engine and pump lost overboard were recovered, and by October 12 pumping was resumed, and on the 21st work in the rock again commenced. Men were employed rapidly until a force of over 900 were at work in the pits. All things seemed to connive at success, which would have resulted, despite the disastrous overflow of September, 1875, had not the tremendous and unprecedented storm and rainfall about the end of December raised the river again. The Montrose dam was heroically held until almost the very top of the rise by Captain Anderson, the overseer, who, with his force, worked nobly night and day. But during the dark hours of the night of January 2, 1876, the rapidly rising waters got the start, further efforts were useless, and the dam was soon reduced to the same condition as in September. Both of these floods, unprecedented at this season of the year, and at a time when low water generally obtains, being wholly unexpected, were unprovided for. The immense structure was overwhelmed, the consequences disastrous: tools and material lost, time expended, gangs disorganized and men demoralized. It was disheartening, but unavoidable. In spite, however, of these misfortunes, the work was nearly completed.

After the second and unprecedented flood of January 2, 1876, it was a mooted question whether to go on or wait until the next season. The matter was referred to the Chief of Engineers, with your recommendation, coinciding with my own, that the work be resumed at once, and by his authority, in a letter of January 15, 1876, repairs were inaugurated, the dam rebuilt, pumping commenced by January 31, and work in

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the channel resumed on February 7, 1876. During a cold snap, experienced while the water was being pumped out, about 6 inches of ice formed in the dam, which, settling on the tracks and in the pit, caused considerable trouble and expense. Again, about February 10, owing to a recurrence of soft weather and heavy rains, the river rose, threatening another overflow. Prompt measures were adopted. The dredge, fortunately, was at hand and was set at work. By energetic and ceaseless labor for three days and nights, the walls of the coffer were raised fast enough to beat the rising waters, and the dam was saved, so that by the 24th of February, when, on account of the exhaustion of the appropriation, it became necessary to stop work entirely, there was a channel 200 feet wide the whole length of the dam, 3,160 feet, and only a small patch at the head that required blasting, and 1 or 2 piles of loose rock on the side to be removed. It was a big undertaking, full of risk, and required constant vigilance and hard work, but the expense account shows that the work has been done for about one-half the cost per yard of the same kind of work that has heretofore been done under contract for the Government, with a result of 43,606.75 cubic yards of rock excavated and placed in spoil-bank, at a cost of about $5 per cubic yard. The spoil-bank runs parallel to the line of channel excavation; is 50 feet removed, located upon the west or Iowa side, and raised above extreme high-water, making an excellent guide for navigation.

COFFER DAM, NO. 2.

This dam incloses a portion of the river immediately above the channel already excavated for an entrance to the guard-lock, and had just been commenced, when the flood of September struck it and washed away all but the protection cribs; when the water had subsided sufficiently, work was resumed and by September 26, the pumps were started and shortly afterward about 300 men were employed excavating the rock from the channel.

Owing to the peculiarly uneven bottom of the river at this point, it was found very difficult to keep the water out of the dam, but considerable experience, and the possession of men skilled in this class of work overcomes these troubles, and by Christmas day of December, 1875, the last blast was fired, the bottom of the channel thoroughly cleaned, the pumps stopped and the dam allowed to fill; finished in 61 days, only 5 days before the disastrous flood that swamped the big dam around the Montrose chain, with a result of 1,752 feet of dam, inclosing 11¼ acres, and 8,469 cubic yards of rock excavated and placed in spoil bank, which bank is located similarly to the one at the upper chain.

ROCK EXCAVATION BY CHISEL-BOAT.

Three of these boats have been employed for the purpose of removing the various patches that interfere with navigation between the upper chain and Nashville crossing.

They continued working to tolerably good advantage with only a few delays caused by inevitable accidents to their machinery, or being forced from their position by careless navigation of rafts, from July, 1875, until November 22, 1875, when on account of heavy ice floating in the river, it was found impracticable to keep them in position, consequently that portion of the work was abandoned temporarily and the boats discharged. As a result of the season's work 3,342.75 cubic yards of rock have been chiseled at a cost of $20,175.41 or $6.04 per yard. This rock has not yet been dredged up, but will be when the necessary funds are available. Nothing has been done on the work during the last 4 months of the fiscal year on account of the exhaustion of the appropriation. In April, the river rose threatening a serious overflow where the bank was weakened by the sluice at the guard-lock having been constructed through it, and but partially completed. A few men were stationed there while the danger existed, and by persevering efforts succeeded in preventing any damage.

This was the highest water experienced since the great flood of 1851, and the whole embankment gave evidence of being substantial enough to withstand almost any rise that may hereafter take place. At the guard-lock the water was within 1½ feet of extreme high-water, and at the lower lock within 3½ feet of that point; this difference is accounted for by the fact that in 1851 the Des Moines River was at flood height, coincident with the flood in the Mississippi, whereas this year it was low and the back water inappreciable. The river continued very high all through the months of May and June, and even, had funds been available, but little could have been accomplished on the section work.

GUARD-LOCK.

Complete preparations were made during the winter and spring of 1875, and great progress was being made at the beginning of the present year; since then the work has been directed almost entirely to the construction of the masonry, which was rapidly pushed toward completion before the advent of freezing weather. The lock-chamber walls were built by two travelers spanning both lock and culvert walls. The tramways, for supporting the travelers, were each 160 feet long; the materials were delivered under the travelers by stone-cars running on tracks leading from the stone-

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yard. This made it an easy matter to deliver the stone on the wall as fast as it could be prepared, it receiving, meanwhile, comparatively little injury. The two travelers were operated 229 days and laid 8,570 cubic yards of masonry, making a daily average of 37.42 cubic yards per day for each traveler. The daily average of masonry laid by derrick at middle-lock sluice was 19.50 cubic yards, and that was a class of work that could be laid much faster than the work on the lock walls, as it comprised no dimension stone, and required very few closers, which cause about one-half the delay attaching to first-class masonry. With these facilities the lock-chamber walls, the miter-sills, the filling and discharge culverts, were all completed by October 21, 1875. This finished all the work that could be done to advantage by travelers; they were accordingly taken down and derricks substituted instead. The circular bank-head on the upper outside of the lock was next completed, and after this, the more difficult undertaking of building the winding wall connecting the lock-wall with the slope-wall on the dike at the upper shore side; in doing this it was necessary to excavate to the solid rock, which was about 14 inches below lock bottom, for one-half the distance through the guard-bank, which prevents the water from flowing into the canal, and against which bank at that time there was a pressure of 10 feet of water. This guard-bank was joined on to a slope wall which is laid over a deposit of loose stone and gravel through which the water percolated quite freely. In view of the great damage which would result from an accident at this place, great precaution was taken, and as fast as there was any excavation made to the rock the wall was laid, and then a good puddle connection was made from that to the the bank, a close watch being kept while any part of it was exposed. This connection is now completed with the exception of about 200 cubic yards of slope and riprap-wall remaining to be laid on the dike above the lock. The next was equally as difficult an undertaking, it being that of building the culverts for feeding or filling the canal; they are connected with the lower outside wing-wall of the lock, which was continued through the canal bank into the river. To make the excavation and build the masonry, it was necessary to build a coffer-dam around the opening connecting with canal bank above and below it; there being about 4 feet of a mud deposit mixed with the lining placed as a protection to the bank, it was a very difficult matter to make a dam that would resist the pressure of the water, and had the dam given away, or had there come a sudden rise in the river, which would overflow it before the walls were in, still greater damages might have been sustained than had the guard-bank given way. Every precaution was taken to render it as secure as possible, and a close watch kept; the walls were pushed forward as fast as the materials could be prepared in order to carry it out of reach of danger. Within two hours after this had been done, and temporary plank gates placed over the culvert openings, the dam was flooded by a rise in the river, and the water came up to within 17 inches of the top of the wall. Owing to the extremely favorable weather during the latter part of the fall, and during December and January, the upper connecting walls and the filling culvert-walls were kept in operation until February 11. On that date work on the guard-lock was suspended on account of the appropriation having been exhausted.

The labor still remaining to be done to complete the guard-lock section, comprises the following work: completing the connecting walls of the filling culverts with the wing-wall of the lock on the upper side, and with the riprap-wall on the canal embankment on the lower side, building the circular wall connecting the wing-wall with the slope-wall on the lower inside of lock, the laying of all the slope-wall, the excavation of the rock in the prism of the canal for 100 feet below the lock, the grading and filling back of the walls, and the completion of the embankment on the outside of the lock. To do all of this will require about three months work with a moderate force.

It is to be exceedingly regretted that this delay has occurred, as had the funds held out, or had a special appropriation been made to keep the work in operation, it would have been an easy matter to complete this lock ready for operation during the low water of this year.

STONE FOR COMPLETING GUARD-LOCK.

The stone for completing the guard-lock has been furnished under an extension of the contract entered into with Messrs. Wells, Timberman & Co., of Keokuk, Iowa, dated September 2, 1874. They filled their entire contract from the Sonora quarry, about 2 miles below this point. The stone is of the very best quality of magnesian limestone that is found in this locality. They complied strictly with their contract, and willingly and faithfully filled all orders as fast as required. They completed their contract finally, October 16, 1875.

HYDRAULIC CEMENT FOR COMPLETING GUARD-LOCK.

You are aware that the cement furnished by the Saint Louis Cement Company (under contract dated October 12, 1874,) was condemned; a statement of which was incorporated in my last annual report, and an application was made for authority to enter into a contract with the "Western Cement Company," they being the next lowest bidders, at the letting held in this office on the 18th of August, 1874. This authority was given, and a contract was accordingly entered into under date of July 20, 1875. The

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Utica cement is well known and has always given good satisfaction on this improvement, where frequent opportunities were had to compare its qualities with other cements. The great facilities established by Clark and Son, of the Western Cement Co., for manufacturing and shipping, and the promptness with which they met all demands made on them deserve commendation. With these excellent and complete arrangements for the supply of materials, and the carrying on of the work, steady and rapid progress was made during the year with a result which is eminently satisfactory.

From an examination of the three locks, the lower and middle locks built by contract and the guard-lock by day's labor, the judgment of any experienced person would pronounce the guard-lock to be far superior to the others in every respect.

LOCK-GATES.

By reference to my last annual report you will see that the work at the beginning of the year was about suspended on account of the oak timber that had been delivered for that purpose being very defective, and it was necessary to await the formality of condemning it and obtain authority to purchase other timber in place of it. This was accordingly obtained and a bill of timber made out to duplicate the whole lot, with the exception of the arch timbers. Instead of making the arch timbers of one solid piece, it was decided to build them of members of from 3 to 4 inches in thickness, which has proved to be a very valuable change, as it is an easy matter to bend pieces of these dimensions, while it took hydraulic pressure to bend the square-timbers. Arrangements were made with Messrs. C. Crane & Co., of Peru, Ind., for the furnishing and delivery of the timber at an exceedingly low price, they representing that they had the timber and facilities to deliver same as fast as it would be required, but in this they completely failed, for when the time had elapsed for them to have completed their contract, they had scarcely begun to deliver any of it. Finally, there was enough delivered to warrant the commencement of the middle lock-gates. This being a very different class of work from that to which most mechanics are ordinarily accustomed, the progress made was quite slow at first, but became more satisfactory afterward. All the timbers in the lock-gates have been put through a process of boiling for a period of from 6 to 8 hours, to free them from the sap. The necessary force of blacksmiths was kept steadily at work, being employed in upsetting all the truss, anchor, and suspension rods to the columns, cutting threads on all these rods and nuts to match, and making the turnbucklers, so that about all this work, with the exception of fitting it in its place, has been done.

The work accomplished thus far is as follows: At the middle lock the 2 lower gates are built in their places and suspended; wickets are all in, and all completed except the planking on the upper side. The 2 upper gates are built, but not suspended to the columns. The wickets are all in, and it will be but a matter of a few days' work to complete and swing them.

At the lower lock the upper gates are built, but are not suspended from the columns. The lower inside gate is built all but putting on a part of the bent timbers and suspended. The preliminary work and the preparation of materials is well advanced, and the labor yet to be done is principally putting up the gates and fitting the iron-work to them. The timber and iron is now on hand, and there will consequently be but little material to purchase. This work was stopped at the close of February on account of the appropriation having been expended. All of this work has been done by days' labor, it requiring principally mechanical and skilled labor, and great pains have been taken to do every part of it in the best manner as the importance of the work demands; and it would be a difficult matter to have it done by contract. All of the tools have been collected into the buildings at each lock and a watchman placed there to look after them. The delivered materials are protected as well as possible to prevent deterioration.

Statement of the cost of the different classes of work in constructing the guard-lock.

[Labor hired by the United States.]

Class of work.	Quantities.	Cost.
Cut-stone masonry ..... cubic yards..	6,916	$5 02
Concrete foundation ..... do.....	48	2 85
Slope wall ..... do.....	229	80
Paving culverts ..... square feet..	1,796	28
Procuring sand ..... cubic yards..	630	79
Earth excavation ..... do.....	15,825	35
Rock excavation ..... do.....	40	1 03
Wrought iron, (in work) ..... pounds	3,611	2½
Cast iron, (in work) ..... do.....	10,650	.00 6-10
Bailing and draining, (7 months) ..... per month..	.....	369 65

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Exhibit of stone delivered at the guard-lock during the fiscal year ending June 30, 1876.

Denomination.	Cubic yards.	Price per yard.	Cost.
Face stone	2,308.26	$13 00	$30,007 38
Backing stone	502 14	7 00	3,514 98
Slope-wall stone	1,553.46	4 00	6,213 84
Total			39,736 20

Exhibit of hydraulic cement delivered at guard-lock during fiscal year ending June 30, 1876.

3,430 barrels of hydraulic cement of 300 pounds each, at $1.99 per barrel.... $6,826 70

MACHINERY FOR OPERATING LOCKS.

In pursuance of the design for the hydraulic machinery for operating the lock-gates, drawings were prepared in the month of August, 1875, and the firm of Sample, McElroy & Co. invited to furnish a proposal for prices of the material and labor required to construct and erect the machinery aforesaid. In compliance with this invitation, Messrs. Sample, McElroy & Co., of Keokuk, Iowa, sent in a proposal dated August 5, 1875, containing prices by weight or measurement for all castings, wrought-iron, chains, wire-rope, and wrought-iron pipe. Also a net price for the steam-engines and boilers. The proposal of Messrs. Sample, McElroy & Co. being accepted, work was at once commenced and carried on until the suspension of all work, February 29, 1876.

In order to prevent delay, the chain, wrought-iron pipe, and wire-rope was ordered at once; the wire-rope being made in lengths required, at the manufactory of Roebling & Sons, Trenton, N. J. All work was transported to the locks as needed, advantageous terms having been made for such transportation, which was done mainly while the roads were in excellent condition for heavy hauling. The stone, brick, and lumber required for the engine-houses were ordered; clean sharp sand for mortar, was obtained from the bed of a neighboring creek, work was commenced on the dressed stone-trimmings and every precaution taken to insure the progress of all portions of the work without delay.

The hydraulic machinery at each lock consists of 4 cylinders, 16 inches diameter by 6-foot stroke, one for operating each set of culvert gates; one cylinder, 16 inches diameter by 6 feet 2 inches stroke, for operating the gates at head of sluice; and 4 cylinders, 9 inches diameter by 5 feet 8 inches stroke, for operating lock gates. These 9 cylinders are connected with the main distributing valve, and are under the complete control of the engineer, at the engine-house. The culvert gates are of cast-iron, sliding on planed cast-iron frames bolted to the stone work, cushions of oak being interposed between the iron frames and the stone. The connections of the machinery are made with wrought and cast-iron gate-stems, ¾-inch iron chain and ½-inch wire rope passing over iron pulleys 24 inches diameter, and connected with the cross-heads on piston-rod by means of adjustable eye-bolts for taking up the slack in chains and rope; leather packing is used on the pistons and piston-rods, and relief valves in pistons remove the pressure as soon as the full stroke is reached.

The connections with lock gates are made with iron chain, kept in position (on the curve of an arc of a circle, whose center is the center of the heel-post,) by iron plates secured to the bottom of the lock; the chain is picked up by pulleys secured under the lower timbers of the gate, is passed over a second set of pulleys at the top of gate, where it is spliced to a ½-inch wire rope which passes around horizontal pulleys at the heel-post, and is rove through a set of seven-fold blocks; these blocks are connected with a ¾-inch wire rope which passes over iron pulleys 30 inches in diameter, and is secured to the cross-heads on piston-rod. The vital principle of this plan being the equalization of the pull at all points in the opening and shutting of the gate.

Water connections between cylinders and the distributing valve at engine-house are made with extra heavy wrought-iron pipe, of 2 inches internal diameter, and patent sleeve-coupling joints; where flange joints were necessary, they were made with thin sheet-copper, between faced cast-iron flanges.

The pipes are laid 4 feet 6 inches below surface of ground, the earth being carefully tamped above them, and no rock used in refilling the trenches. The pipes were carefully staked in position, so that no springing can displace them. Where curves were rendered necessary, the pipes were bent cold on large curves, and many short curves thus avoided. The pipes forming the connection across the lock are supplied with

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drain cocks to draw off all water; the hydraulic cylinders can, by a like arrangement, be drained. All pipes were tested, when laid with a pressure of 350 to 375 pounds per square inch.

The pumping apparatus for supplying pressure to the hydraulic cylinders, consists of an upright steam-engine, stationed on the main floor of the engine-house, and joined to the pump in the basement by a rigid connection of iron columns, bolted to the stone foundation pier. Steam cylinder, 12 inches diameter by 12-inch stroke, operating a double-action piston-pump; pump, 6 inches diameter by 12-inch stroke, with 12 lift-valves, 3 inches diameter, 8 receiving and 4 delivery valves; area of steam-piston 113.09 square inches to 28.27 square inches area of pump, or four to one; mean pressure exerted by pump, 200 pounds to square inch; maximum pressure, 300 pounds to square inch.

Engine furnished with fly-wheels, governor, self-feeding oil-cups, and every appliance to save the close attention of the engineer, which would otherwise be demanded, and the throttle-valve is so placed that the engineer can stop the engine without moving from his place at the distributing-valve; a pipe leading to exterior of building and connected with the pump, furnishes the means for subduing any fire that might occur within the building itself, or any boat passing through the lock.

The boiler for steam-engine is of upright fire-box form, 50 inches diameter, 7 feet high, and having 91 flues 2½ inches diameter; shell of boiler of United States tensile strength iron, $\frac{7}{16}$ inch thick. The boiler supplied with an independent pump, and is also connected with the main pump; is furnished with safety-valves, steam and water gauges, blow-off and gauge-cocks, and 12 brass cleaning-plugs; also a steam-whistle above roof of building for signalling steamboats.

The boilers were inspected before leaving the shops and tested with cold water pressure 150 pounds to the square inch. During the month of February repeated tests were made of the steam pumping-apparatus and the lower culvert gate machinery on both sides, with satisfactory results.

ENGINE HOUSES.

The houses for containing the steam pumping-apparatus at the locks, are built in the most substantial manner and are first-class in every respect. The one at the middle lock is nearly completed, only some interior fittings remain to be finished.

The house at the lower lock has the foundation completed ready for superstructure; about one-half the stone-trimmings are cut ready for use.

The material used in the construction is magnesian limestone for exterior walls and brick for the partition walls. Outside dimensions of house 27 feet 4 inches by 27 feet 4 inches. Thickness of exterior walls, 18 inches. Ashlar work cut with rock face, level beds, and square joints. Window and door-trimmings, arch stones, &c., cut with rock face, margin draught, and jambs tool-dressed. Platforms and steps, hammer-dressed. Cornice, brackets, &c., tool-dressed. The foundations of all exterior and cross walls and the piers for the engine, boiler, and chimney are built of rubble stone, and rest on the solid bed-rock at a distance of from 17 to 19 feet below the level of the lock-wall coping. In the basement is a brick cistern 8 feet in diameter, height to apex of arch 16 feet, divided by a partition wall into filtering and storage compartments. A 6-inch pipe with shut-off cock, supplies water from the lock. The drainage from roof of building is conveyed to the cistern. Main floor of building contains an engine-room, 24 by 13 feet; boiler-room, 10 feet 2 inches by 10 feet 4 inches; coal-room, 13 feet 6 inches by 7 feet. A recess in the engine-room contains the basement stairway. The pumping-room, store-room, and ash-pit, situated in the basement, are all well lighted by windows opening above ground. A large loft under the roof is for the storage of the patterns used on the work. Height of main floor, 11 feet in clear; basement, 6 feet in clear; main floor above lock-wall coping, 4 feet; floor-joists and flooring of Georgia pine—joist, 10 inches by 2 inches—1 foot 3 inches on centers; rafters, 10 inches by 2 inches, pine, 1 foot 3 inches on centers, covered with matched flooring, extra thick felting, and heavy Lehigh slate, 12 inches by 20 inches; copper gutters and flushing, and galvanized iron hippings and water-pipes; a fire-proof floor for boiler-room, with an iron man-hole plate, giving access to ash-pit.

The floor is a brick-groined arch, covered with concrete. The windows of main floor command a view up and down the canal, and of the gates.

SUMMARY.

The engine-house at middle lock, completed excepting the doors, finished flooring and painting and glazing the window-sashes which are made.

The lower gate, and culvert cylinders, 4 in all, are erected, and connections made and enclosing-walls built. Upper gate, and culvert cylinder, east side, are set and water-connections made. All the remaining machinery for the middle lock is either on the ground or at the shops of Sample, McElroy & Co. A short time will suffice to complete the work at this lock.

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LOWER LOCK.

The foundation for the engine-house completed to the level of lock wall and ready for superstructure. Cistern completed, and water-pipes laid excepting those forming the connections across the lock. About one-half the stone trimmings are cut, ready for use. Culvert-gate frames and oak for cushions are ready to use. In excavating for foundations, great difficulty was caused by caving in of banks and the flooding of the pit with water, but these obstacles were successfully overcome.

GUARD-LOCK.

The sluice gates opening from the river are placed in position. When work was suspended, February 29, 1876, all portions of the machinery were protected as far as possible from injury caused by rusting of the several parts; considerable injury however, will result from any protracted delay.

The amount of funds available for this work at the beginning of the fiscal year was:

Balance from last year's appropriation	$101,889 88
Amount appropriated by act of Congress approved March 3, 1875	480,000 00
Total	581,889 88

On June 30, 1876, at the close of the fiscal year the entire amount was expended.

No appropriation has as yet been made for carrying on this work during the fiscal year ending June 30, 1877, but the amount asked for, and which it is hoped will soon be appropriated is $275,584. This amount will complete the work and open the improvement to navigation unless some unforseen cause prevents. Amount required for maintenance of the work during fiscal year ending June 30, 1878, $40,000.

The gentlemen connected with me in the supervision of the work during the past year, have exhibited great zeal, and have performed more than the usual amount of labor; and I feel much indebted to them for the results accomplished in the face of most disheartening difficulties and disasters. The Mississippi River, at this point, was never before known to exhibit such freaks as those of the past season. The cost of the work has consequently been increased, and the time of its completion delayed.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Captain of Engineers, U. S. A.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

N 3.

IMPROVING ROCK ISLAND RAPIDS, MISSISSIPPI RIVER.

Congress appropriated $50,000 for the fiscal year 1875–'76. At the letting of the work, June 17, 1875, Mr. George Williams, of Keokuk, Iowa, was the lowest responsible bidder. The abstract of proposals in relation to the letting was submitted in my last annual report. (See Report of Chief of Engineers for 1875, part I, page 463.) The work of excavation at Lower Chain was commenced in August and finished in November, 1875, excepting the removal of a portion of the coffer-dam *débris*, which was effected in April, 1876. The amount of rock excavation at this place was 2,340.5 cubic yards. I take pleasure in stating that the contractor, Mr. Williams, performed this work with his usual energy and care. As soon as the high stage of water in the river recedes I shall order an investigation in relation to the removed coffer-dam *débris*, and then close his contract by a final estimate and paying him the retained per centage.

At Saint Louis Chain the excavation of 305.44 cubic yards was made by machinery and hired labor. I have already in my letter of October 1, 1875, stated that this experiment turned out to be a success in engineering and in point of economy. I hope that I may be allowed to

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continue the work by hired labor at certain places on Saint Louis, Campbell's and Duck Creek Chains, during the coming year especially if the appropriation for the fiscal year ending June 30, 1877, now pending in the river and harbor bill, should be but $20,000, instead of the $50,000 applied for. The projects with the various maps are ready to be submitted, and it will be seen that even with the small appropriation of $20,000 a comparatively good result for navigation can be gained in removing rock by hired labor. Should but $20,000 be granted by Congress, I shall be obliged to ask for a final appropriation of $50,000 for the completion of the improvement.

From my annual report of 1874 and 1875, it will be seen that the improvement at the foot of Moline Chain has been considered the closing stone of the work, and this could not be accomplished on account of the insufficient appropriations granted by Congress for several years.

New and careful additions by a hydrographic survey of last fall exhibit the amount of rock at this final work to be about 2,500 cubic yards.

The current at the Moline Chain is very rapid, exceeding, at a stage of low-water, 8 feet per second, and some of the patches of rock to be removed lie in the middle of the channel, and others intrude into it.

Coffer-dam building is out of question, as it would stop navigation, and the rock must therefore be taken out by chisel and dredge, and even these implements are here subjected to such difficulties as to increase the price per cubic yard considerably higher than on any other chain. As I stated in my last report, $18 per cubic yard will not be too high an estimate, and based upon this supposition, an appropriation of $50,000 for this important closing work at Moline Chain is respectfully applied for for the fiscal year ending June 30, 1878.

I most earnestly recommend this final work of closing the Rock Island Rapids improvement to the consideration of Congress, adding at the same time that the improvement thus far has proved to be a perfect success.

For further information in detail in regard to operations during the fiscal year ending June 30, 1876, I beg leave to refer you to the report of Assistant Engineer E. F. Hoffmann, which is herewith submitted.

Money statement.

Amount available July 1, 1875	$52,432 03
Amount expended during fiscal year ending June 30, 1876	46,702 87
Amount available July 1, 1876, including $2,808.60 due on contracts	5,729 16
Amount appropriated by act approved August 14, 1876	25,000 00
Amount (estimated) required for completion of existing project	50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	50,000 00

REPORT OF MR. E. F. HOFFMANN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 1, 1876.

COLONEL: I have the honor to submit my annual report of operations for the improvement of the Rock Island Rapids of the Mississippi River during the fiscal year ending June 30, 1876.

For applying the appropriation of $50,000 made on the 3d of March, 1875, for the work of improving Rock Island Rapids of the Mississippi River, your project of April 21, 1875, submitted to the Chief of Engineers United States Army, recommended:

1st. The continuance of excavation at Lower Chain, this work to be done by contract, as there was none of the requisite equipment for doing it ourselves, and the cost of such equipment would be so great as to leave no margin for the payment of wages.

2d. For accomplishing the small amount of work required at Saint Louis Chain, this

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work to be done by hired labor and machinery. You stated that, by taking advantage of the low water at the usual time in the latter part of the summer or in the fall, the work could be reached by the workmen standing upon platforms supported upon tripods resting upon the bottom of the river, and you added that it was your belief that the work could be done for less than any contractor would undertake so small a piece of work.

Your programme received the approval of the Chief of Engineers, and you were authorized to advertise the work at Lower Chain; in consequence of which, on the the 17th of June, 1875, Mr. George Williams, of Keokuk, appeared to be the lowest responsible bidder, and a contract was entered into with him, for doing the work of excavation at Lower Chain, at a price of $12 per cubic yard, to be removed from the bed of the Mississippi by means of a coffer-dam. The price of $12, including all preparatory work, such as building the coffer-dam, bailing, blasting, and removing the rock.

I.—WORK OF EXCAVATION AT LOWER CHAIN DONE BY CONTRACT.

Owing to the fact that the contractor, Mr. George Williams, had entered into an agreement for the hire of dredge and other implements at the Des Moines Rapid Improvement of the Mississippi River, he could not commence this work until August 21, when he began with his accustomed energy. In three days—on August 21, 23, and 24—he sunk 12 cribs for the purpose of building a breakwater, previous to erecting the head of the coffer-dam. These cribs were 12 feet by 12 feet, and 12 feet by 16 feet standing in 11 feet of water.

On August 26 the first corner of the coffer-dam was sunk, and on 3d of September 1,480 running feet of coffer-dam had been built, and the same closed. The dam was on the head and on the side toward the Iowa shore 10 feet, and on side toward the Illinois shore 8 feet in width, standing in a depth of water varying from 8 to 12 feet.

Pumping was gradually commenced on the 4th of September and continued to the 8th of September, when a portion of the lower part of the dam, about 140 feet, broke, and the water whirled with great vehemence chisel-boat, flatboats, and the boat with the machine-shop from their moorings through the opening into the coffer-dam, smashing the pumps and boats quite seriously and endangering the life of several workmen. In a few minutes the dam was filled.

The water had been rising for some days, and continued to be at a high stage for several weeks, so that the work at the dam was abandoned.

On October 7 the contractor resumed work in closing the break, which was effected on the 15th of October, and in course of 4 days the water was bailed out by means of two 12-inch rotary pumps, and the bottom of the river laid bare.

The quantity of rock in the pit of the coffer-dam was determined by a careful level survey, which showed an amount of 2,340.5 cubic yards, distributed over an area of 63,428 square feet. The estimate for this work, based upon the previous hydrographic survey made by the sounding machine, exhibited an amount of 2,427.70 cubic yards, or showed a difference of 87 cubic yards, or 3.8 per cent. I will state that the difference between a carefully-made level survey and a hydrographic survey made by means of the sounding machine used at these works, has never shown a larger difference in the percentage than 4 per cent at different chains where such comparison has been established.

The result might be called a very fair one, when I add that the comparison is based upon 13 coffer-dams, varying in size from 3 to 42 acres, and in cubical measure from 800 cubic yards to 17,000 cubic yards.

From the 20th of October to the 8th of November the contractor worked an average of 160 men in the pit of the coffer-dam, and had between 8 and 10 teams engaged, which hauled the blasted rock out of the pit to the crest of the coffer-dam, and from there to flat-boats moored to the dam. The contractor towed the loaded flat-boats, by steamer, a mile down the river, to a point on the Iowa shore, where the city of Davenport availed herself of your permission to use the removed rock for the improvement of her streets. Powder was used for an explosive, and the firing done by fuse. In the average the rock being a limestone of minor hardness, it blasted well and facilitated the work. When the work was reported to be finished, a final survey with the level was made, which showed that the contractor had done a most excellent work. The bottom of the pit, where excavation had been effected, was so smooth and plane that the level never found a point higher than the given grade, and varying from 0 to 0.2 of a foot below grade. Your paragraph in the advertisement from the year 1871, according to which you stated that no payment would be made for any excavation below grade, be it occasioned by stratification or any other reason, has acted very beneficially at the different works on the rapids. It has taught contractors to keep close to grade by taking more care in judging quantity of powder, depth of drill-holes, and the appropriate use of sledge-hammer.

After the inspection, you gave leave to remove the coffer-dam and cribs, which work,

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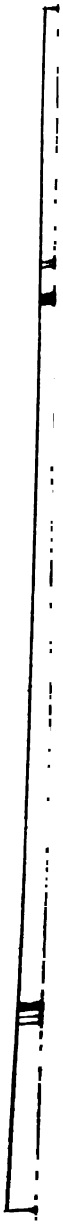

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although it was immediately commenced, had to be abandoned at the end of November on account of the heavy ice running in the river. In the month of April, 1876, the contractor resumed the work of removing the *débris* of coffer-dams and cribs, and stated that, in his belief, the work was finished.

The very high and unusually long high-water stage has prevented until now an inspection with the sounding machine, to which, with your permission, an improvement in the shape of a rake has been attached. It consists of 13 divisions, upon a length of 100 feet; each division has two perpendicular wooden poles, adjustable in joints to the respective depth to grade, which are connected at the lower end with ¼-inch iron rod.

The machine moves slowly up stream over the places where the work is said to have been effected. In case it strikes against the smallest remnant of obstructions above the line of grade, the wooden pole or poles in one or more sections will break and indicate the place where the *débris* have not been removed. As the length of the rake on the machine is 100 feet, it is not probable that anything can be missed. The rake is a most useful improvement on the sounding machine.

As soon as the stage of water permits, this investigation with the rake will be made at Lower Chain, and a final estimate can then be given, and the contractor paid the retained percentage on the work.

A copy of the estimates and payments to Mr. George Williams is as follows:

Quantity of work, &c.	Contract price.	Amounts.	Percentage retained.	Amount of payment.
Estimate No. 1.				
Estimated amount of work done from the 7th to 31st of October, 1875, inclusive:				
1,200 cubic yards of rock excavation and removal at Lower Chain	$12 00	$14,400 00	$1,440 00	$12,960 00
Estimate No. 2.				
From the 1st to 8th of November, 1875, inclusive. Total amount of work done:				
2,340.5 cubic yards of rock excavation and removing at Lower Chain	12 00	28,086 00	2,808 60	25,277 40
Deduct previous estimate		14,400 00	1,440 00	12,960 00
		13,686 00	1,368 60	12,317 40
Present estimate.				
Estimated amount of work performed from the 1st to 8th November, 1875, inclusive:				
1,140.5 cubic yards of rock excavation and removing at Lower Chain	12 00	13,686 00	1,368 60	12,317 40

II.—WORK OF EXCAVATION AT SAINT LOUIS ROCK, DONE BY HIRED LABOR AND MACHINERY.

Saint Louis Rock was located in the center of the steamboat channel at the head of Saint Louis Chain, opposite Fulton's Island. It was situated about 1,200 feet from either shore, and consisted of a high patch of magnesian-limestone rock, containing about 305 cubic yards.

The location and extent of this rock had never been fully ascertained by this office until surveyed and located in the fall of 1874 with the sounding apparatus pertaining to the Rock Island Rapids improvement. During the progress of the work daily reference was made to the maps from our last surveys above named.

On Monday, July 19, 1875, the party left Rock Island on a flat-boat 70 feet long by 13 feet in width, loaded with a camp outfit and material for constructing such machinery and apparatus as should be needed in prosecuting the work. It was brought up to Fulton's Island by the steamer C. J. Caffrey, and landed there Monday night.

On the following day camp was established, and, until August 1, time was employed in the construction of tripods and derrick, and in fitting up the flat-boat in such a manner as to enable its use for the work.

On August 3, the flat-boat was removed from the shore and placed in position above Saint Louis Rock, and a large tripod over the highest part of the rock was planted. This tripod was made of 6 inches by 6 inches timbers, 35 feet long, and so constructed that each side, and the space inclosed between the points of the legs, consisted of an equilateral triangle, with side 35 feet in length. The points of the legs were shod with iron points to prevent slipping. When the tripod was lowered into the river-bottom, braces 3 inches by 12 inches, and as long as required, were spiked on to the legs at the surface of the water, and planks placed across the braces constituted a triangular platform, from which the work of drilling was carried on. As needed, other tripods were con-

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structed and placed in reference to the first and each other in such a manner that the space between them could also be covered with platforms, and thus the whole surface of the rock was covered with a working platform which could be moved at will. All the trouble and uncertainty caused by working from a floating platform was in this way avoided. In order to manage the flat-boat with ease, and to be able to place it in any position the work or circumstances might require, an anchor up stream with a line some 700 feet long, running to a powerful crab on the bow of the flat-boat, was placed. Also, two side anchors were dropped on each side of the flat-boat some 300 feet distant, having anchor lines running to the bow of the flat-boat from each side, and anchor lines running through snatch-blocks on each side of the after end of the boat to two small crabs placed near the center of the flat-boat. (See sketch No. 1.)

The arrangements made for lifting rock and tripods were as follows: 24 feet from the end of the flat-boat was a strong mast, 45 feet high, braced with strong guys 6 feet from the foot of the mast, and between the mast and the after-end of the boat a foot-block, 13 feet long, 14 inches by 10 inches, was placed, which was bolted to the deck and braced by four pieces of 6 inches by 6 inches, timber 6 feet long. (See sketch No. 2.)

In seats cut into this foot-block rested a pair of shears, of timbers 40 feet long 9 inches by 7 inches at the foot, and tapering to 7 inches by 5 inches, with a spread of 10 feet over all the bottom, being 7 inches by 5 inches at the apex, and bound together at the apex by an iron band 2 inches by ¼ inch, with rings above and below for the rigging.

At the foot of the mast was a crab, geared 5 to 1, and used with block and tackle for raising and lowering the shears. A similar crab and rigging was placed in the framework of the shears for raising and lowering weights, and in using rock was raised out of the water by the crab and rigging of the shears, and then the shears themselves raised and the rock swung over the boat and was lowered on to the deck. (See sketch No. 3.)

By these means it was possible to lift and move the tripods into any position desirable, and also to raise rock weighing up to 6,000 pounds and deposit them on the flat-boat.

The drilling was done from the platforms in and around the tripods by using three men to one drill. A set of men working in this manner could drill from 30 to 35 feet of hole 2¼ inches in diameter per day, and a drill would last for about two days before it would need to be resharpened. The depth of cutting varied from 1 to 5 feet. Two, and sometimes three, sets of three men each were kept constantly drilling, while the remainder were employed lifting rock and in general work.

The cartridges used were formed of rubber sheeting (the common merchantable article) and were from 12 inches to 36 inches in length, 2 inches in diameter, according to circumstances. The small cartridges for exploding the charges were filled with ¼ of a cubic inch of pulverized powder. Into this powder the ends of the two copper wires leading to the Voltaic battery were inserted and connected with a fine platinum wire. This small cartridge was put into the larger cartridge ⅔ its depth, which was then filled with the common F F blasting powder. In immediate connection with the cartridge containing the charge, short insulated wire was used, which proceeded from the cartridge along an iron rod ¼ inch in diameter and about 10 feet in length. This rod helped to stiffen the cartridge and enable the workmen to place it into the hole drilled for it. Afterwards, the charge was tamped with sand by means of a long wooden funnel, the wires leading from the charge were then connected with those leading to the battery, the battery placed in the acid, and the charge exploded. After the explosion the battery was removed from the acid and, by means of a small pair of davits, swung over the side of the flat-boat into the water, and the action of the water kept the plates always clean and ready for future use. In blasting pains were taken to break the rock into as large pieces as possible, as pieces containing from 20 to 40 cubic feet could be removed with greater ease and less trouble than the same amount of rock broken into small fragments. Two, and sometimes three, men were employed working in the water adjusting chains, tongs or lewis to the broken rock and severing small fragments by use of hand tools. In hoisting the larger rocks a lewis was used which consisted of a ringbolt, with the bolt a foot long or longer when required, and with the end of the bolt split for 6 inches. A flat steel wedge ½ inch in thickness was inserted into the split of the bolt and the bolt itself placed into the hole of the rock and driven firmly in. The tackle then was hooked into the ring, when the stone was lifted on to deck of the flat-boat. In removing the lewis a slight strain was taken on the ring and the bolt struck with a hammer a few times, when the bolt would become loose, and being removed, was ready for use again. For lifting bowlders or irregular pieces of rock out of the water in a rapid current, this form of lewis was better adapted to the work than any other. By these means, and with only hand power, several rocks containing 42 cubic feet were raised. The greater part of the larger rocks were removed and placed on shore, while the small ones were generally dumped into deep holes.

When it became necessary to remove rock to shore on the flat-boat, a long anchor-line

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was used which enabled the flat-boat to swing into the shore and back again. By these means the work of blasting and removing rock was carried on until September 15, 1875, when, having finished the excavation of Saint Louis Rock, and the rapid rising of the river preventing attention being paid to several small patches in the vicinity of Saint Louis Rock, which can be removed in a future season, the flat-boat was dismantled and the party discharged.

I add the within statement:

From July 19 to August 1, camp was established, tripods, derricks, and platforms were built, and the flat-boat fitted with shears.

During the 1st week in August, 444 cubic feet of rock were removed; during the 2d week in August, 1,293 cubic feet of rock were removed; during the 3d week in August, 1,209 cubic feet of rock were removed; during the 4th week in August, 1,902 cubic feet of rock were removed; from August 29 to September 4, 2,108 cubic feet of rock were removed; from September 4 to September 9, 1,291 cubic feet of rock were removed, amounting in all to 8,247 cubic feet, or 305.44 cubic yards of rock.

From September 9 until September 15, the party was engaged in dismantling the machinery and in storing away the material and apparatus for future use.

During the season 240 holes were drilled, 350 pounds of powder were used, 960 feet of holes were drilled and from 1 to 2½ pounds of powder used to each charge, according to the depth of the hole and position of the rock.

The United States Engineer Office is under obligation to Maj. D. W. Flagler, Ordnance Corps, United States Army, Commanding Rock Island Arsenal, who, upon application, was so kind as to loan three powerful crabs and some tools for drilling holes. In reference to the work at Saint Louis Rock, I copy from your letter to the Chief of Engineers dated October 1, 1875, the following:

"The work of excavation of rock at Saint Louis Chain, which was executed by means of hired labor and machinery, has been pushed vigorously. On the 15th of September 305 cubic yards had been removed from that place, giving a depth of 4½ feet to navigating steamers and rafts in dead low-water of 1864. I am glad to state that the work at Saint Louis Chain has been effected in a thorough manner, and that a saving of $1,480 is shown by the *modus operandi* with hired labor, in comparison with the contract work with chisel and dredge, as heretofore practiced at similar detached work. The 305 cubic yards of removed rock would have cost the Government when done under contract $16 per cubic yard, equal to $4,880, whereas the cost of doing the work by our own party, including all incidentals, amounts to only $3,400, showing the saving above named. Beside this I have to say, that the purchase of material for doing such kind of work, viz, anchors, rope, steel, sledge-hammers, battery, wire-rope, &c., is included in the above stated sum. The material used in executing the work, and on hand for being used again, represents a sum of $700. Should this sum be deducted from the entire cost of $3,400, the removal of rock per cubic yard would be about $8.85."

While the excavation was going on at Saint Louis Chain, some incidental work had to be accomplished at the foot of Campbell's Chain. The running ice had severed from the margin of the channel several pieces of rock and thrown them into the middle of the same. The rock at this chain is a soft magnesian limestone, very much honeycombed, and by the action of the ice these pieces were broken off. One piece, containing about 2½ cubic yards, was at the low stage of water very near the surface, and endangered navigation seriously. With your permission the flat-boat with crew was towed to the foot of Campbell's Chain, and a day's blasting cleared the channel of this obstruction.

The hydrographic survey, with the sounding-apparatus pertaining to this work, has furnished, during the year, most valuable additions to the hydrographic general and special maps of the rapids.

The cuts of the different chains were all sounded for the purpose of ascertaining if the ice had washed obstructions into the channel; also the places where chisel and dredge had been used for excavation of rock, underwent an inspection.

Upon the suggestion of several pilots, a part of the river about ¼ of a mile below Duck Creek Chain was surveyed. The plotted hydrographic map of this place showed that the idea of improving this section, called by the pilots, "Cottonwood Chain," was merely a supposition, based upon little knowledge of the channel of the river.

Finally, with your permission, a day was spent in sounding the river above Moline Chain along the Illinois shore, for enabling the commanding officer of Rock Island arsenal, Col. D. W. Flagler, United States Army, to compute certain calculations by the plotted map of the same, in regard to the Moline water-power. The above-mentioned hydrographic survey commenced on the 1st of October, and was closed on the 21st of the same month.

After the ice commenced to run, the machine was hauled out of the water; was blocked up and remained on shore till the month of May, 1876, when she was calked, painted, and made ready for use again. The next work with her and the attached rake, will be at the lower chain as soon as the stage of water permits.

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In the office during the winter, assistants have been employed in plotting the hydrographic survey of last, fall, with a view of collecting from the maps such information as will enable you to submit, at the proper time, recommendations for the prosecution of the work of improving these rapids, in accordance with the appropriation to be granted by Congress. Should the appropriation of $50,000, asked by you in your last report for finishing the work of the rapids, fail, and but $20,000 be granted, according to the river and harbor bill, now pending in Congress, for the fiscal year 1876-1877, the smallness of the amount will then only allow you to propose the removal of small patches of rock and bowlders near Saint Louis, Duck Creek, and Campbell's Chain, to be executed by hired labor and machinery, which was so economically carried on last year, and the final and closing work at the foot of Moline Chain, stated in the annual reports of 1874 and 1875, must then be made the subject of another and last appropriation.

All the maps and calculations necessary for a project to be submitted by you to the Chief of Engineers are ready; and, in reference to the estimates of rock based upon the maps, I state that they are carefully compiled. Observations of velocity and direction of the current at Moline Chain in the fall of last year recommended a small variation from the project of 1874 and 1875.

The amount of rock to be removed is 2,505.8 cubic yards; and as this work will probably have to be done under a new and final appropriation, I can but repeat the words which I used in my last annual report in reference to the matter, as follows:

"I most respectfully entreat you to recommend this remaining work to the favorable consideration of the higher authorities and Congress, as a subject of another and last appropriation for the fiscal year 1877-'78. This last work represents the closing-stone of an undertaking which stands in the history of improved rivers on this and the other side of the ocean unparalleled, and which, in the accomplished and undenied benefit extended to the navigation, proves to be of the greatest advantage to the bordering States of the river and a perfect success in engineering."

The current at the Moline Chain exceeds in some places 8 feet velocity per second; and, as the rock to be removed lies in the middle of the channel, chisel and dredge are recommended to dispose of these scattered patches. I am confident that at this chain no bid under $18 per cubic yard will be received on account of the difficulties experienced by working chisel and dredge in the middle of such a swift current in the channel, and an appropriation of $50,000 for the fiscal year 1877-'78 would fully cover the cost of work, the difficult engineering, superintending, and contingencies, and finish the improvements of the Rock Island Rapids of the Mississippi River, as above stated.

I submit a table, showing amount of rock excavated at the different chains during the years 1867 to 1875, inclusive:

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Table exhibiting the amount of rock excavated at the Rock Island Rapids of the Mississippi River during the years from 1867 to 1875, inclusive.

	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	Total.
	Cub. yds.	*Cub. yds.*	*Cub. yds.*	*Cub. yds.*	*Cub. yds.*	*Cub. yds.*	*Cub. yds.*	*Cub. yds.*	*Cub. yds.*	
Duck Creek Chain	5, 508. 49	4, 479. 74	585. 46	.....	.....	.....	.....	.....	.....	10, 573. 69
Moline Chain	.....	15, 757. 41	1, 917. 17	.....	.....	.....	.....	.....	.....	17, 674. 58
Sycamore Chain	.....	177. 90	17, 579. 36	245. 18	.....	.....	.....	.....	.....	18, 002. 44
Campbell's Chain	.....	.....	3, 706. 00	4, 984. 98	.....	.....	220. 00	.....	.....	8, 910. 98
Smith's Chain	.....	.....	.....	.....	10, 338. 87	791. 30	.....	.....	.....	11, 130. 17
Patches between Sycamore and Smith's Chain	.....	.....	.....	.....	1, 722. 30	1, 594. 71	.....	.....	.....	3, 317. 01
Crab Island Patches	.....	.....	.....	.....	2, 524. 30	409. 00	.....	.....	.....	2, 933. 30
Saint Louis Chain	.....	.....	.....	.....	.....	2, 575. 20	.....	.....	305. 44	2, 880. 64
Winnebago Island Patches	.....	.....	.....	.....	.....	1, 200. 00	944. 00	.....	.....	2, 144. 00
Above Duck Creek Chain	.....	.....	.....	.....	.....	.....	800. 00	.....	.....	800. 00
Lower Chain	.....	.....	.....	.....	.....	.....	680. 00	2, 649. 60	2, 340. 05	5, 670. 10
Crib below Lower Chain	.....	.....	.....	.....	.....	.....	25. 00	.....	.....	25. 00
Foot of Campbell's Chain	.....	.....	.....	.....	.....	.....	296. 00	.....	.....	296. 00
Total	5, 508. 49	20, 415. 05	23, 787. 99	5, 230. 16	14, 585. 47	6, 570. 21	2, 965. 00	2, 649. 60	2, 645. 94	84, 357. 91

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I take great pleasure in bringing to your notice the faithful and efficient services rendered by Assistant Engineer C. H. Beuck at the work of excavation at Lower Chain by means of a coffer-dam and those of Mr. John F. Wallace, assistant engineer, who superintended the work of subaqueous blasting at Saint Louis Chain. Both gentlemen were aided from time to time by Assistant E. Cramer, and draughtsman, Mr. A. Stibolt, who deserve full credit for the accurate observations by theodolite in the hydrographic survey of last fall.

All of which is respectfully submitted by your most obedient servant,

E. F. HOFFMANN,
Assistant Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

N 4.

IMPROVING ILLINOIS RIVER.

The report of Assistant Engineer R. A. Brown, herewith submitted, gives the details of the progress of the Illinois River improvement during the fiscal year ending June 30, 1876.

As in former years, for the purpose of affording immediate relief to navigation, channels of sufficient width for the passage of steamers have been opened through the various bars upon which work has been carried on during the past year, and should funds be provided hereafter for the purpose, the channels may be widened.

During the months of August and September, the work was somewhat delayed by the prevalence of high water and the breaking out of malarial fever in the contractor's and engineer's parties, but in October and November and up to the 17th of December, when operations were interrupted by running ice, the work was carried on vigorously and with most satisfactory results.

Much credit is due the contractor, whose superintendent, Mr. H. S. Brown, has displayed great zeal and readiness in carrying out the terms of the contract.

During the winter the equipment was placed in thorough repair and every arrangement made for prosecuting the work with vigor, but owing to the continued high water during the spring, work could not be resumed until the 29th May, 1876. For reasons mentioned above, the contractor, finding he could not complete his contract by the 30th of June. the specified time, made application for an extension, which was granted, and the time extended to October 31, 1876.

It will be seen from Mr. Brown's report that the results of the construction of low dams, jetties, and training-walls are very satisfactory, and amply justify the continuance of the same method of improvement.

During the past year numerous surveys and resurveys have been made of the various bars, with a view to ascertaining the practical results of the work thus far performed, and for the purpose of projecting new work for the coming year, and making estimates for the fiscal year ending June 30, 1878.

Mr. Brown renews his suggestion that an equipment may be purchased, at a cost not to exceed $20,000, so that it may always be in readiness and at the command of the engineer in charge to be employed in restoring such channels as may become obstructed, and also to work gradually in increasing the width of the channels that have been improved; and I recommend that authority be granted to procure, from the appropriation anticipated for the year ending June 30, 1877, a dredge and its usual equipments, at a cost not to exceed $20,000; but should the ap-

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propriation expected for the current fiscal year be too small to justify the procuring of such equipment, I would then recommend that authority be obtained for purchasing it from the appropriation of $120,000 asked for improving Illinois River in the fiscal year ending June 30, 1878.

Money statement.

Amount available July 1, 1875	$113,126 42
Amount expended during fiscal year ending June 30, 1876	73,434 56
Amount available July 1, 1876, including $3,020.95 due on contracts	39,691 86
Amount appropriated by act approved August 14, 1876	40,000 00
Amount (estimated) required for completion of existing project	120,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	80,000 00

REPORT OF MR. R. A. BROWN, ASSISTANT ENGINEER.

UNITED STATES QUARTER-BOAT MAJOR E. F. HOFFMANN,
At Slim Island Bar, June 30, 1876.

COLONEL: For the improvement of the Illinois River during the fiscal year ending June 30, 1876, I beg leave to submit the following report of operations:

At the close of the fiscal year ending June 30, 1875, work was progressing at Naples Flats, with three dredges, and the full equipment operating twelve hours per day.

Having provided a channel throughout the bar, (as shown in tabular statement D, appended,) on the 31st of July last the fleet was moved to Spar Island Bar, and immediately commenced work at that point, but, owing to severe rain-storms, causing a stage of water too high for doing satisfactory work, operations were suspended from the 4th to the 11th of August, and even then were prosecuted to great disadvantage. High water continued during the month of August and the greater part of September. Malarial fevers also contributed to our troubles to a great extent. During September, the superintendent and his associate, two foremen of dredges, the pilots and engineers of two tow-boats, were indisposed, several of whom were obliged to leave the work for medical attendance. Of the engineer party, at the close of the month, all but three members were on the sick-list, making the duties of the well very arduous; but by employing a few laborers, and taking advantage of circumstances, together with the judicious and liberal use of quinine, no delay occurred in the prosecution of the work on the part of the contractor.

Having completed the improvement of Spar Island and School-house Bars, on the 26th of September the equipment was moved to French Bar, for the purpose of completing the work left in an unfinished condition last season.

The month of October proved very favorable for work, as the stage of water was a mean of 4.4 feet, that of July, August, and September being 8.2, 9.3, and 7.6 feet, respectively. The sanitary condition of the contractor's force also greatly improved, thus giving a good showing in the advancement of the work, which was prosecuted at Apple Creek, Pearl Shoals, and McKee's Creek Bar with little interruption up to the 17th of December, when running ice forced the dredges and equipment to the banks. The superintendent, for the contractor, here took the precaution to move into winter quarters, as the probabilities were against further effective operations for the season. Arrangements had already been made to make a thorough repairing of machinery during winter; accordingly, the dredges were soon dismantled, and on the return of favorable weather were not in condition to resume work, unfortunately, for the winter proved very mild and favorable for active operations, a state of affairs entirely unexpected.

Attempts to prosecute work on this river during the winter season, in former years, having proved futile, the contractor, through his superintendent, Mr. H. S. Brown, gave his whole attention to the repairs of his equipment, and with the best of results.

Dredge No. 4 has been entirely rebuilt, the impaired machinery being replaced by new. Dredges Nos. 2 and 3 have been thoroughly repaired; likewise the tow-boats, dump-scows, and flat-boats.

The present plant is in the most efficient condition of any ever before provided for this work, and consists of 3 dredges, Nos. 2, 3, and 4; 2 steamboats; 1 steam pile-driver, (mounted on a flat-boat;) 6 dump-scows, (nearly new;) and 5 decked flat-boats, besides a liberal stock of other implements.

The contractor's superintendent, Mr. H. S. Brown, shows commendable zeal not only in providing an equipment capable of pushing the work, but in giving his personal attention to details during its progress.

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On the first of March, with few exceptions, the plant was in order for resuming work, but the stage of water prevented—the mean for the month being 12.9 feet; that for April was 17 feet, thus bringing the time for the resumption of operations down to nearly the close of the fiscal year. The contractor, seeing that this protracted delay would not allow him to complete his work at the specified time, on the 8th of May made application to have the time extended to the 31st of October, 1876. The application, being favorably indorsed by you, the time was extended.

On the 29th of May, after a suspension of 164 days, the river having receded to a 11.1-foot stage, referred to low-water, the contractor was instructed to commence work at Naples Bar, (lower crossing,) this being the most favorable locality.

Operations have continued up to the close of the year, with the results mentioned elsewhere.

Operations during the year have been conducted under two contracts; that of George Williams, of Keoknk, Ohio, dated September 14, 1874, having been extended to the 31st of October, 1875.

The amount of work performed under this contract during the fiscal year is as follows, viz:

Quantities.	Items.	Localities.	Price.	Amount.
28,944 cubic yards	Earth-excavation	Naples Flats	$0 25	$7,236 00
7,583 cubic yards	....do	Spar Island	25	1,895 75
15,898 cubic yards	....do	School House	25	3,974 50
17,604 cubic yards	....do	French Bar	25	4,401 00
2 hours' work, dredge	Snagging	Naples Flats	10 00	20 00
2 h. and 50 m. work, dredge	....do	French Bar	10 00	29 64
11 hours' work, dredge	Casting on dams	School House	10 00	110 00
1,380 linear feet	Piling in dam No. 1	....do	15	207 00
527.2 cords	Brush in dam No. 1	....do	2 25	1,186 20
808 9-10 cubic yards	Stone in dam No. 1	....do	2 00	1,617 80
2,265 linear feet	Piling in dams	Spar Island	15	339 75
495 9-10 cords	Brush in dams	....do	2 25	1,115 77
Total				22,134 61
The amount expended under this contract per last annual report was				37,363 30
Total expended under this contract				60,497 91

Copy of final estimate (No. 11) of work done by George Williams, under his contract for the improvement of the Illinois River, dated September 14, 1874.

Total amount of work done, including retained percentage	$60,497 91
Deduct former payments, as per receipted vouchers	54,439 12
Balance due	6,048 79

Under the contract with William Patrick, of Phœnix, Oswego County, N. Y., dated May 31, 1875, the amount of work done is shown by the following statement, viz:

Quantities.	Items.	Locality.	Price.	Amount.
18,053 cubic yards	Earth-excavation	Apple Creek Bar	$0 28	$5,054 84
4,298 cubic yards	....do	Pearl Shoals	0 28	1,203 44
32,901 cubic yards	....do	McKee's Creek Bar	0 28	9,212 28
7,315 cubic yards	....do	Naples Bar, (lower crossing)	0 28	2,048 20
12,483 cubic yards	....do	Little Blue River Bar	0 28	3,495 24
10,000 cubic yards	....do	Slim Island Bar	0 28	2,800 00
28½ hours' work	Casting on dam	School house Bar	11 00	313 50
1½ hours' work	Snagging	Apple Creek Bar	11 00	13 75
33 hours' work	Moving to and casting on dam	Spar Island Bar	11 00	363 00
1 hour's work	Snagging	Naples Bar	11 00	11 00
6 27-60 hours' work	....do	Little Blue River Bar	11 00	70 95
477 5-10 cubic yards	Stone in dam Nos. 1 and 2	Spar Island Bar	2 50	1,193 25
945 linear feet	Piles driven in dam No. 2	Pearl Shoals	0 15	141 75
525 cords	Brush in dam No. 2	....do	2 50	1,312 50
424 5-10 cubic yards	Stone in dam No. 2	....do	2 50	1,061 25
720 linear feet	Piles driven in dam No. 2	Buckhorn Bar	0 15	108 00
418 4-10 cords	Brush in dam No. 2	....do	2 50	1,044 00
304 cubic yards	Stone in dam No. 2	....do	2 50	760 00
Total				30,209 45

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MATERIAL RESULTS OF THE YEAR.

A channel 4 feet in depth is provided through Naples Flats, 100 feet wide for 2,400 feet through the upper section, and 105 feet wide for 6,200 feet throughout the lower section. The total length of channel is 8,600 feet, 4,000 feet having been completed last year; also at this point is constructed with dredged material some 1,300 linear feet of earth-dike.

A channel at Spar Island Bar 1,500 feet in length, 150 feet wide, and 4 feet deep; also, 1,400 feet of earth-dike, built with dredged material.

A channel at School House Bar 2,400 feet in length, 150 feet wide, and 4 feet deep; also, 1,100 linear feet of earth-dike, built with dredged material, revetted with rubble stone.

At French Bar the channel provided last season was widened 1 cut, making its present width 110 feet throughout the entire length of the bar, 8,700 feet. Two hundred and fifty feet (linear) of earth-dike was built with dredged material; also, the dike of 1874 re-enforced.

At Apple Creek Bar was opened a channel through the upper section 150 feet wide for 1,700 feet, and through the lower section 120 feet wide and 1,650 feet in length. With this dredged material was constructed some 2,600 linear feet of earth-dike.

At dam No. 2, Pearl Shoals, was provided a channel 900 feet in length, 120 feet wide, and 4 feet deep. The dredged material was placed on the brush and stone dam with scows.

At McKee's Creek Bar the dimensions of the improved channel are 3,100 feet in length, 120 feet wide, and 4 feet deep. The excavated material was used in backing the dam, closing the chute, also in the construction of 500 linear feet of earth-dike, projecting from the west shore, closing the old channel.

At Naples Bar, lower crossing, the channel made in 1872 has been widened; also, a greater depth provided by the removal of lumps. Some 300 linear feet of earth-dike built, projecting from the east shore.

The improvement of Little Blue River Bar will insure a channel 140 feet wide and 4 feet in depth. Length of cut, 1,500 feet. With the dredged material, consisting of bowlders, rubble, shingle, gravel, sand, and shells, in constructing a cross-dam 500 feet in length, projecting from the west shore, closing the old channel.

All the depths given above are referred to low water.

The channel at Slim Island Bar is yet unfinished. The approximate estimate of work done is 10,000 cubic yards.

DAMS AND JETTIES.

At School House Bar is constructed, of piling, brush, and stone, backed with earth, a dam closing the east chute. Length, 800 feet; base, 36.2 feet; height, 5.4 feet, (mean dimensions;) height above low water, 3 feet.

The cost per cubic yard is 75.6 cents for brush and stone; 26.8 cents for earth. Total cost per cubic yard, 58.4 cents; cost per linear foot, 3.27\frac{3}{10}$.

At Spar Island Bar is constructed, of piling, brush, and stone, dam No. 1, 680 feet length; base, 35 feet; height, 5 feet; backed with earth cast on with a dredge. This closes Otwell's Chute. Dam No. 2, 200 feet in length, same base and height as No. 1. This closes Spar Island Chute. The cost per cubic yard is 93.7 cents for brush and stone, 25$\frac{1}{2}$ cents for earth. Total cost of dam per cubic yard, 72.7 cents. Cost per linear foot of dam, $3.43.

At Pearl Shoals was built, of piling, brush, and stone, dam No. 2, 850 feet in length, including training-wall; base, 35.6 feet; height, 5.2 feet, (mean dimensions,) backed with dredged material put in place with dump-scows. Cost of brush and stone, 95.7 cents per cubic yard; cost of earth, nothing. Total cost of dam per cubic yard, 52.2 cents; cost per linear foot, $3.30. This dam is for the purpose of contracting the low-water channel, the river at this point being some 1,300 feet wide, and very shallow.

Dam No. 1 is located about 1 mile above. It is not yet completed. The piles driven last season for its construction, collected, during the high water of July and August last, a large amount of drift, making at the time a very effective dam, but of a rude nature. Should the drift remain as collected it will answer our purpose very well; if not, it is proposed to complete it in the regular manner.

The chute east of Buckhorn Island is closed with a dam of piling, brush and stone. The mean dimensions are, length 650 feet, base 38 feet, height 6 feet.

The piles driven last season, as an experiment, proved insufficient to close the chute in a satisfactory manner.

The total cost of the dam is $3,041.57, including last year's work. Cost per cubic yard of brush and stone, 1.12\frac{7}{10}$. Cost per linear foot of dam, $4.68.

This work was completed on the 22d of November. Owing to the lateness of the season it was deemed inexpedient to commence new work. Experience teaches that it is not prudent to leave work in an unfinished condition during the winter or high-water seasons. Accordingly, the equipment was moved into winter quarters at Naples.

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Our experience in the construction of brush and stone dams is very satisfactory. The specifications and plans are followed closely and with good results. The entire mass of brush is held in position by one line of piling and fully bonded together in 1 mattress (consisting of several courses) which remains on the water-surface and sub-surface until the ballast is thrown on from scows, causing the mass to sink regularly to the bottom, after which it is generally backed or re-enforced with earth cast up with a dredge or dumped from scows. The mattress is built with a down-stream batter of one on three, the up-stream batter of 1 on 4.

SURVEYS.

During the year detailed surveys of the following bars have been made before and after dredging, viz:

The upper section of Naples Flats, Spar Island, School House, Apple Creek, French, Pearl Shoals, McKee's Creek, Naples, (lower crossing,) and Little Blue River. Also preliminary surveys of Silver Creek, Grand Pass, Buckhorn, Bevington, Florence, Little Blue River, Meredosia Island, Naples, (lower crossing,) Slim Island, Bedford, and Pilot's Peak Bars were made during the months of October, November, December, and June, for the purpose of planning work for the present season.

The extreme high stage of the river prevailing during the season rendered the surveys very laborious.

During the present working season, should the stage of water be favorable, I wish to make resurveys of most of the bars on the section of the river extending from Naples to Havana, for the purpose of planning future work; also to ascertain if any changes have taken place in the improved channels.

The bars where work is planned for the present season being generally short, will, in connection with the work before referred to, require quite active operations on the part of the engineering party. A large field force will therefore be a necessity in order to prosecute the work advantageously and with due economy. Transient men can be employed in many cases to advantage, pecuniarily and otherwise.

PLANS FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

Owing to the high stage of the river during July, August, and September last, and the protracted season of high water the last spring, a number of bars mentioned in my last annual report, in "Plans for the present working season," were not reached, which accounts for the repetition here.

List of bars to be improved.	Estimated cub. yards.
Bevington	14,000
Florence	4,000
Slim Island and Bedford	13,000
Pilot's Peak	16,000
Buckhorn	15,000
Grand Pass	15,000
Otwell's	11,000
Silver Creek	40,000
Hurricane Island	8,000
Twelve-Mile Island	25,000
Six-Mile Island	30,000
Total cubic yards, approximate	191,000

ESTIMATE.

191,000 cubic yards earth excavation, at 28 cents	$53,480
Estimated cost of dams	9,520
Estimated cost of engineering and contingencies	7,000
Total estimated cost of improvement below Big Blue River, near Naples	70,000

Should no unforeseen obstacle prevent, the present available balance, together with the anticipated appropriation for the fiscal year ending June 30, 1877, will be ample to complete the improvement as above estimated.

In case points on the river demand attention before the list of bars is improved, I would suggest a change of programme for the purpose.

I would most respectfully renew the suggestion given in my last annual report, viz, that authority be obtained at an early day to purchase such an equipment as will answer the requirements of this work, the cost not to exceed $20,000.

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Advantage could then be taken of the market for the purchase, and at the close of the contract work, when the improvement would be sufficiently advanced to allow of its being continued with the smaller equipment, the Government would be in readiness to operate on its own account to advantage.

A detailed estimate of cost of purchasing and operating a dredge and equipment is herewith submitted, as one argument in favor of this project.

Another is, the operatives can be employed direct; and with the prices mentioned in the estimate, the most skillful, energetic, and faithful men can be secured.

The equipment can thus be kept in an efficient condition, always in readiness to operate at points wherever desired, and at short notice. The above conditions are not always sure.

The reason for not recommending this project at present is, that in order to push the work to early completion, it would necessitate the purchase of a much greater plant than would be needed in the maintenance of the improvement; a loss in the sale of surplus would probably accrue.

The plan, lately pursued, of cutting narrow channels, seems to be generally popular, as it enables us to expedite the work materially, thereby giving more direct relief to navigation.

As shown by estimate herewith submitted, the additional width can be provided in these cuts by the employment of a plant owned and managed by Government direct, at a less cost than by the present contract system.

My report for the last fiscal year gave the original estimate for the completion of this work by the system of dredging and constructing dams and jetties		$391,912 00
There has since been appropriated—		
In 1870	$100,000	
In 1873, (allotted)	20,000	
In 1873, June 23	75,000	
In 1875, March 3	75,000	
Total expended and pledged for the work		270,000 00
Balance to be appropriated under the original estimate		121,912 00

Owing to circumstances of different natures, such as underestimates (for want of sufficient data) on some of the bars in the lower river, delays incident to the failure to receive funds in sufficient amounts, the protracted high-water season, &c., the estimate of the cost of its completion should be revised, in order to show the propriety of applying for means in excess of the original estimate.

For the section of river below Big Blue River, an estimate is given under the head of "Plans for the fiscal year ending June 30, 1877."

The bars remaining unimproved, for which no fund is provided, are situated in the section of river extending from Big Blue River, Pike County, to Havana, and are as follows, viz: Big Blue River, Meredosia Island, Meredosia, Wilson's Island, Eagle Island, Indian Creek, Beaver Dam, bar at Beardstown, Sugar Creek Island, Dutchman's Creek, Sanganion, Grand Island, and Spoon River Bars.

The approximate amount of earth-excavation is 300,000 cubic yards.

ESTIMATED COST OF COMPLETING AND MAINTAINING THE IMPROVEMENT.

(The list of bars is given above.)

300,000 cubic yards earth-excavation, (dredging,) at 25 cents	$75,000 00
4,500 linear feet of brush, and stone dams, at $3.33⅓	15,000 00
Contingent expenses and engineering	10,000 00
Total cost of works to be constructed	100,000 00
Estimated cost of dredge and equipment to be used in maintaining and widening the channel, (details given elsewhere)	20,000 00
Total	120,000 00

This amount could profitably be expended for the purposes above mentioned during the fiscal year ending June 30, 1878.

MAINTENANCE.

After the work estimated in this report is performed, annual appropriations of $20,000 would be required for a few years to operate the equipment, until the additional width is provided in the channels already cut; then a less fund would probably be sufficient for the maintenance of the improvement.

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Estimate of cost of purchasing and running a dredge and equipment on Government account.

COST OF PLANT.

One dredge, (capacity, 350 cubic yards per day)	$11,000
One tow-boat	5,000
Three dump-scows, (side-pockets,) $750 each	2,250
One flat-boat, (deck)	500
Tools, lines, &c	1,250
Total cost	20,000

COST OF RUNNING DREDGE.

One engineer, 12 months, at $125 per month	$1,500	
One crane-man, 12 months, at $60 per month	720	
One fireman, 9 months, at $60 per month	540	
Two deck-hands, 9 months, at $100 per month	900	
One watchman, 9 months, at $50 per month	450	
Twenty-five bushels coal, at 12 cents, $3 per day, 225 days	675	
Oil, waste, and repairs, $2 per day, 225 days	450	
		5,235

TOW-BOAT.

One pilot and master, 10 months, at $100 per month	1,000	
One engineer, 9 months, at $80 per month	720	
One fireman, 9 months, at $60 per month	540	
One deck-hand, 9 months, at $50 per month	450	
Thirty bushels coal, at 12 cents, $3.60 per day, 300 days	1,080	
Oil, waste, repairs, and contingencies, $4 per day, 300 days	1,200	
		4,990
Engineering and contingencies for one year		9,775
Total cost for operating one year		20,000
Estimate of work accomplished in 225 days, (cubic yards)		78,750
Cost per cubic yard		$0.25.4

The tabular statements herewith submitted will give some idea of the importance of this river in regard to domestic trade.

It will be noticed that the statements are intended to show the comparative rank it takes with other western rivers. The country it drains is too well known to call for any description. As an agricultural district it has no superior. Nature has been remarkably generous in its provisions, not only in regard to soil and climate, but in forming an outlet for its productions.

I can call to mind no transportation-route where such quick and satisfactory results can be obtained in the expenditure of the public funds as on this river. It is to be regretted that sufficient means have not been provided to complete the improvement long ere this.

Appended to this report are sheets A, B, C, and D, giving condensed statements of work performed and results obtained, as well as other information. Maps are nearly completed (scale, $\frac{1}{3600}$) showing the condition of bars before and after improvement; also plan, elevation, and transverse section of dams.

Most respectfully submitted.

Your most obedient servant,

R. A. BROWN.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

From the "Annual Statement of the Trade and Commerce of Saint Louis for the year 1875, reported to the Merchants' Exchange of Saint Louis by George H. Morgan, secretary," are compiled the appended tables, showing interesting details of the trade of this line of transportation as compared with other routes.

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TABLE I.—*Showing the amount of freight, in tons, received at and shipped from Saint Louis by the following routes:*

RECEIVED.

Rivers.	1875.	1874.	1873.	1872.	1871.
Upper Mississippi	198,100	231,060	281,175	242,584	236,887
Lower Mississippi	128,020	169,780	226,535	295,960	313,211
Illinois	153,995	192,770	125,715	175,370	146,000
Missouri	30,160	44,830	38,630	26,895	72,579
Red, Ouachita, Arkansas, and White	100	340	1,075	3,720	4,176
Ohio, Cumberland, and Tennessee	153,150	93,985	127,925	119,390	111,548

SHIPPED.

Rivers.	1875.	1874.	1873.	1872.	1871.
Upper Mississippi	96,225	95,800	61,966	55,235	78,967
Lower Mississippi	367,235	469,065	525,445	543,666	477,970
Illinois	18,470	13,740	11,695	15,930	10,936
Missouri	25,100	20,390	27,810	27,536	44,438
Red, Ouachita, Arkansas, and White	1,480	5,445	34,640	32,690	42,995
Cumberland and Tennessee	1,560	2,225	2,140	2,040	2,534
Ohio	129,025	100,660	119,660	127,985	112,652

TABLE II.—*Showing the entire movement in flour and grain, by rivers, for* 1875.

RECEIPTS.

Rivers.	Flour.	Wheat.	Corn.	Oats.	Rye.	Barley.
	Barrels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Upper Mississippi	91,529	748,968	832,486	1,050,440	15,791	241,901
Lower Mississippi	68,115	656,363	13,112	117	4,297	4,853
Illinois	16,873	276,951	954,680	75,574	4,630	1,083
Missouri	2,082	352,098	156,900	85,504	8,080	483
Ohio, Cumberland, and Tennessee	.....	315	.....	.....	.....	.....
Red, Ouachita, Arkansas, and White	.....	3,060	.....	.....	.....	.....

EXPORTS.

Rivers.	Flour.	Wheat.	Corn.	Oats.	Rye.	Barley.
	Barrels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
New Orleans boats	505,248	156,179	824,977	1,282,383	5,101	4,011
Vicksburg boats	147,972	11,513	385,447	227,565	2,196	168
Memphis boats	142,519	20,126	156,077	140,787	4,090	560
Cumberland and Tennessee	400	.....	.....	1,800	.....	.....
Red, Ouachita, and Arkansas	900	.....	35,000	1,350	775	.....
Upper Mississippi	5,623	131,103	458	860	704	2,912
Ohio	2,489	9,292	3,783	4,595	.....	3,614
Illinois	18,894	61,501	3,117	148	666	289
Missouri	754	585	12,455	819	65	1,554

TABLE III.—*Showing receipts of hog-product at Saint Louis by rivers for* 1875.

Route.	Pork.	Cut meat.	Bacon.	Lard.
	Barrels.	*Pounds.*	*Pounds.*	*Pounds.*
Upper Mississippi	14,030	1,904,982	1,946,153	603,625
Lower Mississippi	127	23,300	82,965	166,325
Illinois	14,508	952,198	453,349	510,340
Missouri	15	44,040	315,972	29,490

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TABLE IV.—*Showing the receipts of hogs at Saint Louis for seven years.*

Route.	1875.	1874.	1873.	1872.	1871.	1870.	1869.
Upper Mississippi	35,681	29,827	20,080	28,482	13,850	26,430	22,299
Lower Mississippi	1,462	3,986	2,645	1,806	1,111	2,920	8,103
Illinois	22,047	11,319	8,543	10,458	6,403	7,550	19,086
Missouri	6,854	21,099	15,580	19,340	20,156	14,851	15,679

TABLE V.—*Showing the receipts of live stock at Saint Louis*, 1875.

Route.	Cattle.	Sheep.	Hogs.	Horses and mules.
	Head.	*Head.*	*Head.*	*Head.*
Upper Mississippi River boats	10,937	9,622	35,631	2,850
Lower Mississippi River boats	1,251	1,374	1,462	194
Illinois River boats	2,139	2,811	22,047	530
Missouri River boats	2,095	2,633	6,854	366

TABLE VI.—*Showing the receipts and shipments of hay and salt at Saint Louis in* 1875.

Route.	Hay, bales.		Salt receipts.	
	Receipts.	Shipments.	Sacks.	Barrels.
Upper Mississippi River boats	67,634	524	.....	660
Lower Mississippi River boats	58	104,334	89,936	5
Illinois River boats	5,077	.....	104	4,658
Ohio River boats	.....	.....	.....	230,683
Missouri River boats	344	.....	.....	.....
Other rivers	.....	3,356	.....	.....

TABLE VII.—*Showing the number of trips made by the Illinois River packets in* 1875.

	From Saint Louis to—	
	Naples.	Peoria.
Saint Louis and Naples Packet Company	115	.....
Saint Louis and Peoria Packet Company	.....	67
Other boats, (estimated)	.....	50

TOWING AND ICE BUSINESS.

In addition to the above statistics of trade of the Illinois River, can be mentioned 10 tow-boats, estimated mean tonnage 225 tons; tonnage of barges not known. Some of these boats take grain-barges, with a capacity of from 25,000 to 40,000 bushels each, direct to New Orleans without breaking bulk. The cargoes are there transferred direct to ocean vessels for Europe. The estimated ice-product for 1875 is 150,000 tons.

R. A. BROWN.

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A.—*Abstract of contracts for improving the Illinois River in force during the fiscal year ending June 30, 1876.*

Name and residence of contractor.	Date of contract.	Subject of contract.	Earth-excavation, (dredging,) per cubic yard.	For constructing dams, riprap, and jetties, per cubic yard.	For furnishing and driving piles, per linear foot.
George Williams, Keokuk, Iowa	Sept. 14, 1874	Material and labor	$0 15	$3 00	$0 15
William Patrick, Phœnix, N. Y.	May 31, 1875	....do	15	.....	15

Name and residence of contractor.	Date of contract.	Subject of contract.	For furnishing and putting in place—			Remarks.
			Brush, per cord.	Rubble-stone, per cubic yard.	For working one or more dredges, manned and equipped complete, each per hour.	
George Williams, Keokuk, Iowa.	Sept. 14, 1874	Material and labor.	$2 25	$2 00	$10 00	Contract completed October 31, 1875.
William Patrick, Phœnix, N. Y.	May 31, 1875	....do	2 50	2 50	11 00	Contract extended to October 31, 1876.

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B.—*Table showing the stage of water in the Illinois River during the fiscal year ending June 30, 1876, at Naples and points on the work extending 40 miles below.*

[The zero of reference is low-water of 1867.]

Day.	1875.						1876.					
	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.
1	6.6	8.9	6.9	7.9	2.5	3.4	4.5	8.0	11.7	16.5	14.7	10.4
2	7.3	10.7	6.6	7.5	2.8	3.3	5.0	7.9	11.6	16.8	14.4	10.2
3	9.5	11.6	6.4	7.1	3.0	3.2	6.0	8.0	11.4	17.0	14.0	9.8
4	10.2	11.9	6.1	6.8	3.1	3.2	7.3	8.0	11.3	17.1	13.7	9.6
5	9.9	12.1	5.8	6.4	3.2	3.2	7.8	8.3	11.2	17.1	13.4	9.4
6	9.9	11.9	5.6	6.0	3.3	3.2	8.1	9.0	11.1	17.2	13.2	9.2
7	9.8	11.1	5.3	5.8	3.4	3.3	8.0	8.5	11.1	17.3	13.9	9.0
8	9.9	10.2	5.0	5.6	3.4	3.3	7.8	8.1	11.0	17.5	14.4	8.7
9	10.0	9.6	4.8	5.6	4.0	3.4	7.6	7.8	11.1	17.5	14.5	8.6
10	10.1	9.5	6.2	5.6	4.3	3.6	7.4	7.7	11.1	17.6	14.6	8.5
11	10.3	9.5	7.9	5.4	4.1	3.7	7.6	7.9	11.3	17.5	14.7	8.4
12	10.4	9.5	8.6	5.3	4.2	3.7	7.8	8.3	11.6	17.4	15.1	8.0
13	10.4	9.5	9.1	5.3	4.1	3.8	7.8	8.6	11.7	17.5	15.2	7.9
14	10.2	9.4	9.4	*3.5	4.0	3.9	7.5	8.6	11.8	17.5	15.4	7.6
15	10.1	9.3	9.5	3.5	4.6	4.0	7.4	8.7	12.0	17.5	15.3	7.4
16	9.7	9.2	9.3	3.5	4.5	4.0	7.3	8.8	12.3	17.5	15.1	7.2
17	8.9	9.3	8.9	3.5	4.3	4.0	7.2	9.1	12.6	17.5	15.0	7.0
18	8.2	9.1	8.6	3.5	4.3	4.2	7.1	9.4	12.9	17.6	14.7	7.1
19	7.6	8.9	8.3	3.5	4.2	4.3	7.1	9.8	13.3	17.5	14.5	7.5
20	7.0	8.8	8.0	3.5	4.0	4.2	7.2	10.3	13.6	17.4	14.2	8.0
21	6.7	8.6	7.8	3.4	3.9	3.9	7.7	10.7	13.8	17.1	13.8	8.2
22	6.5	8.4	7.6	3.4	3.8	3.9	7.8	11.1	14.3	16.9	13.5	8.3
23	6.2	8.3	7.4	3.3	3.8	3.8	7.6	11.4	14.7	16.8	13.1	8.3
24	6.2	8.7	7.2	3.2	3.7	3.8	7.5	11.7	15.1	16.6	12.8	8.5
25	5.9	8.5	6.9	3.1	3.7	3.8	7.6	11.9	15.7	16.3	12.4	.....
26	5.6	8.3	9.7	3.0	3.6	3.9	7.6	11.9	16.0	16.0	12.1	.....
27	5.3	8.1	9.5	2.8	3.5	4.1	7.6	12.0	16.1	15.9	11.7	.....
28	5.6	7.8	9.1	2.7	3.5	4.3	7.7	11.9	16.3	15.7	11.4	.....
29	6.4	7.6	8.7	2.7	3.4	4.4	7.7	11.8	16.3	15.3	†11.1	.....
30	6.4	7.4	8.3	2.5	3.4	4.4	7.8	.....	16.4	15.0	10.9	.....
31	6.7	7.1	.....	2.4	.....	4.4	8.0	.....	16.4	.....	10.6	.....
Mean	8.2	9.3	7.6	4.4	3.7	3.7	7.3	9.8	12.9	17.0	13.6	8.4

*Change in locality. †Resumed work.

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C.—*Statement showing cost, &c., of dams and jetties constructed during the fiscal year ending June 30, 1875 and 1876, for the improvement of the Illinois River. To accompany report of Col. J. N. Macomb, Corps of Engineers, U. S. A., for fiscal year ending June 30, 1876.*

Date of construction.		Locality.	Total cost.	Mean dimensions.			Number of cubic yards.			Cost per cubic yard.			Cost per linear foot.	Remarks.
Year.	Month.			Length.	Base.	Depth.	Brush and stone.	Earth.	Total.	Brush and stone.	Earth.	Total.		
				Feet.	*Feet.*	*Feet.*								
1874.....	October.....	French Bar	$460 37	.....	.....	.....	167.2	.....	167.2	$2 75	.....	$2 75	.....	Smith's Chute closed with piling. Banks protected with brush and stone.
1874, '75..	September, October, and November.	....do	.....	7,000	150	3.0	.....	60,000	60,000	.....	.....	.....	.....	Some 7,000 linear feet of earth-dike built with dredged material.
1874, '76..	October, June ..	Bedford Chute	1,203 75	330	39.5	6.5	1,572	6,000	7,572	76½	.....	16	$3 64.7	Built with piling, brush, and stone, backed with dredged material.
1874.....	March	Sugar Creek Bar..	.....	800	216	4.0	.....	19,200	19,200	.....	.....	.....	.....	Some 800 linear feet of earth-dike built with dredged material.
1875.....	April and May..	....do	.....	5,300	110	4.5	.....	48,500	48,500	.....	.....	.....	.....	Sugar Creek Island Chute closed and some 5,000 linear feet of earth dike built with dredged material.
1875.....	May and June ..	Naples Flats	2,207 50	1,100	32.9	4.3	2,850	3,300	6,150	77.4	.....	35.9	2 00.6	Cross-dam and training-wall built with piling, brush, and stone, backed with dredged material.
1875.....	June and July ..	....do	.....	2,600	150	7.0	.....	50,000	50,000	.....	.....	.....	.....	About 2,600 linear feet of earth-dike built with dredged material.
1875.....	July	Gar Island Chute .	206 00	100	31.1	3.7	217	.....	217	95	.....	95	2 06	Gar Island Chute closed by dam built with piling, brush, and stone.
1875.....	June and November.	McKee's Island Chute.	560 37	250	33.8	4.6	725	750	1,475	77.2	.....	38	2 24	Chute closed by dam built with piling, brush, and stone, backed with dredged material.
1875.....	November and December.	....do	.....	500	150	4.5	.....	12,500	12,500	.....	.....	.....	.....	About 500 feet of earth-dike built with dredged material.
1875.....	October.....	School House Bar.	2,616 90	800	36.2	5.4	2,899	1,580	4,479	75.6	$0 26.8	58.4	3 27.2	Chute closed by dam built with piling, brush, and stone, backed by dredged material.
1875.....	September and October.	....do	817 60	1,100	120	6.5	*408.8	15,898	16,306.8	*2 00	.....	.....	*74	Some 1,100 linear feet of earth-dike built with dredged material, riprapped with stone.
1875.....	October and November.	Apple Creek Bar..	.....	2,600	90	4.0	.....	18,053	18,053	.....	.....	.....	.....	Some 2,600 linear feet of earth-dike built with dredged material.
1875.....	October and November.	Spar Island Bar, Nos. 1 and 2.	3,012 27	880	35.0	5.0	2,828	1,320	4,148	93.7	27½	72.7	3 43	Built of piling, brush, and stone; No. 2 backed with earth cast up by dredge.

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C.—*Statement showing cost, &c., of dams and jetties constructed during the fiscal year endind June 20, 1875 and 1876.*—Continued.

Date of consrruction.		Locality.	Total cost.	Mean dimensions.			Number of cubic yards.			Cost per cubic yard.			Cost per linear foot.	Remarks.
Year	Month.			Length.	Base.	Depth.	Brush and stone.	Earth.	Total.	Brush and stone.	Earth.	Total.		
				Feet.	*Feet.*	*Feet.*								
1875	August	....do		1,400	90	3.2		7,583	7,583					Some 1,400 linear feet of earth-dike built with dredged material.
1875	November	Pearl Shoals	2,799 00	850	35.6	5.2	2,912	2,550	5,462	95.7		52.2	3 30	Built of piling, brush, and stone, backed with dredged material.
1875	November	Buckhorn Chute	3,041 57	650	38.0	6.0	2,711		2,711	1 12.2		1 12.2	4 68	Built of piling, brush, and stone.
1876	May and June	Naples Bar, lower crossing.		300	75.0	9.0		7,315	7,315					About 300 linear feet of earth-dike built with dredged material.
1876	June	Little Blue River Bar.		500	80.0	8.0		12,483	12,483					About 500 linear feet of stone and earth-dike built with dredged material.

* Stone.

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D.—*Table showing the amount of work performed and results obtained for the improvement of the Illinois River during the fiscal year ending June 30, 1876; to accompany annual report of Col. J. N. Macomb, Corps of Engineers, U. S. A.*

Date.		Name of bar.	Cubic yards of earth excavation.	Price per cubic yard.	Cost of dredging.	Dimensions of channel at low-water.						Time of dredge employed by the hour, and character of work.		Cost per hour.	Total cost of time-work.
						Before improvement (approximate.)			After improvement.						
Year.	Month.					Length.	Width.	Depth.	Length.	Width.	Depth.	Casting on dams.	Snagging.		
						Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*H. m.*	*H. m.*		
1875	July	Naples Flats	28,944	$0 25	$7,236 00	8,600	25	2.0	8,600	105	4.0	.....	2 00	$10	$20 00
1875	August	Spar Island	7,583	25	1,895 75	1,500	100	3.0	1,500	150	4.0	33 00	.....	11	363 00
1875	August and September	School-House	15,898	25	3,974 50	2,400	50	2.5	2,400	150	4.0	11 00 28 00	.....	10 11	423 50
1875	September and October	French	17,604	25	4,401 00	8,700	50	2.0	8,700	110	4.0	.....	2 05	10	20 84
1875	October and November	Apple Creek	18,053	28	5,054 84	3,350	50	3.0	1,700 1,650	150 120	4.0 4.0	.....	1 15	11	13 75
1875	November	Pearl Shoals	4,298	28	1,203 44	900	100	3.0	900	120	4.0	.....	.....	.....	.....
1875	November	Buckhorn	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1875, '76	Nov., December, and June	McKee's Creek	32,901	28	9,212 28	3,100	50	2.5	3,100	120	4.0	.....	.....	.....	.....
1876	May and June	Naples Bar, (lower crossing)	7,315	28	2,048 20	1,200	50	3.0	1,200	140	4.0	.....	1 00	11	11 00
1876	June	Little Blue River Bar	12,483	28	3,495 24	1,500	50	2.5	1,500	140	4.0	.....	6 45	11	70 95
1876	June	Slim Island Bar*	10,000	28	2,800 00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Date.		Name of bar.	Construction of dams and jetties—brush and stone dams.								Remarks.
			No. of linear feet.	Cost per linear foot.	No. of cubic yards.	Cost per cubic yard.	Cost of backing.	Total cost.	Cost per cubic yard, gross.	No. of linear feet of dike built with dredged material.	
Year.	Month.										
1875	July	Naples Flats	.....	.....	.....	.....	.....	.....	.....	1,300	
1875	August	Spar Island	880	$3 43	2,892	$0 93.7	$363 00	$3,012 27	$0 72.7	1,400	
1875	August and September	School-House	800	3 27	2,899	75.6	423 50	2,616 90	58.4	1,100	
1875	September and October	French	.....	.....	.....	.....	.....	.....	.....	250	Also, dike of 1874 re-enforced.
1875	October and November	Apple Creek	.....	.....	.....	.....	.....	.....	.....	2,600	
1875	November	Pearl Shoals	850	3 30	2,912	95.7	Nothing	2,799 00	52.2	.....	
1875	November	Buckhorn	600	5 06.9	2,711	1 12.2	Nothing	3,041 57	1 12.2	.....	
1875, '76	Nov., December, and June	McKee's Creek	250	2 24	725	77.2	Nothing	560 37	38	500	
1876	May and June	Naples Bar, (lower crossing)	.....	.....	.....	.....	.....	.....	.....	300	
1876	June	Little Blue River Bar	.....	.....	.....	.....	.....	.....	.....	500	
1876	June	Slim Island Bar*	.....	.....	.....	.....	.....	.....	.....	.....	6,000 cubic yards of dredged material put on Bedford Chute dam.

* Unfinished.

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N 5.

SURVEY OF HARBOR AT FORT MADISON, IOWA.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., December 6, 1875.

SIR: I beg leave to transmit herewith a report of Mr. C. W. Durham, assistant engineer, on the survey at Fort Madison, Iowa, made in August, 1875.

In my letter of February 1, 1875, transmitting a report of Mr. M. Meigs, assistant engineer, on an examination of this locality, I asked for a special appropriation of $1,000 for making a detailed survey in order to obtain sufficient data for a proper consideration of the subject.

Your letter of April 20, 1875, contained instructions for making surveys at Fort Madison and Burlington, Iowa, and informed me of an allotment of $2,000 from the appropriation "for examination, surveys, &c., to enable me to carry them into effect.

By letter of July 26, I instructed Mr. Durham, who was then conducting the survey of the "Upper Mississippi River route," to make special surveys at Fort Madison and Burlington on arriving in their neighborhood.

It will be seen from his report that the sand-bar forming in front of the town has increased to such an extent as to blockade almost the entire city front, and has extended entirely across the main channel, so that in a few years, unless its growth is checked, the town will be entirely insulated, and the main channel closed to navigation. This trouble, which is a very serious one, not only to the town, but also to the navigation of the Upper Mississippi in general, arises from a gradually-increasing diversion of water into Niota Chute, so that at present about two-fifths of the water passes that way.

To utilize Niota Chute as a channel to steamboats would require great expense, as at its lower end it is much obstructed by bowlders and ledges of rock.

Mr. Durham proposes a project which will not only remove the obstructions to *general* navigation at this point, but will also *incidentally* free Fort Madison from its incubus, and open the river down to Montrose, at the head of Des Moines Rapids, and give additional effect to the United States improvement in that locality, now nearly completed.

This project calls for the construction of a riprap dam across the head of Niota Chute; a smaller subsidiary dam to aid in giving effect to the large one; the removal of a small ledge of rock near the Niota side, which endangers navigation and interferes greatly with boats landing at Niota; the dredging of the upper portion of the bar and cutting a passage through the same in order to facilitate the scour of the current subsequent to the building of the large dam.

The location of the proposed dams is shown on the map accompanying the report, as also of the ledge of rock mentioned above, and that portion of the bar which it is desirable to dredge out.

To carry out this project would require, according to Mr. Durham's estimates, $30,000.

I approve of the project of assistant engineer Durham, and respectfully recommend that an appropriation be asked for with which to carry it out.

Very respectfully, your most obedient servant,

J. N. MACOMB,
Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

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REPORT OF MR. C. W. DURHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., November 30, 1875.

SIR: I have the honor to present herewith my report on the survey of a portion of the Mississippi River in the vicinity of Fort Madison, Iowa.

On the 26th July, I received from you instructions to the following effect: "In prosecuting the surveys for the improvement of the Mississippi River, you will, on reaching the vicinity of Fort Madison, Iowa, make a special survey from above that city to such point below it as you may find necessary to enable you to make a plan and estimate for the improvement at that point, so as to make the approaches to the levee easy at all stages of the water."

In accordance with these instructions, I began the survey on the 18th of August. A transit-line was run down the right bank, beginning about half a mile above Upper Penitentiary Creek and extending a mile below town. Numerous triangulations were made and compass-lines run for filling in details of the survey. All of the lines were referenced. A line of levels was run along the right bank, (profile shown on map,) and numerous water-surfaces were taken and bench-marks established. A comparison of the records of the water-gauge on the railroad-bridge at Burlington with those of the gauge at Mechanic's Rock, Des Moines Rapids, enabled me to ascertain the *low-water* elevation of the river-surface with considerable accuracy, and this elevation has been used as a *datum* to which all other elevations are referred.

About 3,000 soundings were made, all of which were carefully located by theodolites, and these have been plotted as taken, and show the various depths at a stage of 1 foot *above extreme low water*, which was the stage of the river during the sounding operations.

Inasmuch as the United States improvement at Des Moines Rapids, a few miles below Fort Madison, is intended to give a channel-depth of 5 *feet at extreme low water*, I have followed the same design in forming plans and estimates for improvement at this point. Contour-lines in blue have been drawn on the map showing the limits of the 5-foot channel at *low water*. A gauge of the main channel between Island No. 14 and the Iowa shore was made, as well as of Niota Chute between Island No. 14 and the Illinois shore.

The steamboat-channel formerly ran in close to the Iowa shore along the entire city front from the mouth of Lower Penitentiary Creek to Atlee's Mill Point, but of late years it has gradually shifted toward the other side of the river, and shows an increasing tendency to turn down Niota Chute. A bar has been gradually forming in front of the city, and at the date of the survey extended up river some distance above Cedar street and entirely across the main river to the head of Island No. 14, so that at *low water* the main channel would be completely blocked to boats drawing 5 feet of water. The water in Niota Chute is somewhat better, and would be taken by steamers were it not that at its lower end it is obstructed by large bowlders and ledges of rock.

In the main channel, about 2 miles below the town, another sand-bar has formed, extending entirely across the channel, and even more difficult to navigation than the one immediately in front of the city. Several other places are met with of more or less difficulty, before the Niota Chute joins the main river at the foot of Island No. 14.

Although the *petition* which led to the present survey prayed for relief as regards the *sand-bar in front of the city*, I have thought proper to make the removal of this bar a matter of *secondary* moment, as being of chiefly *local* importance, and have accordingly prepared my plans and estimates looking toward the removal of the obstructions to general navigation; inasmuch as the reasons for attempting the improvement would be far *stronger*, and at the same time such improvement would also, from its *nature*, remove the *disability* under which the city is lying, thus serving a double purpose.

It is obvious that the cause of the *growth* of this bar, before mentioned, as blocking up the city front and the entire main channel, is owing to the gradually-increasing diversion of the water from the main river into Niota Chute.

A cross-section and gauge of the main channel and chute, taken August 25, 1875, at a stage of 1 foot above low water, shows—

Main channel, 21.029 cubic feet per second;
Niota Chute, 14.511 cubic feet per second;

or, about two-fifths of the water passes down Niota Chute.

If, then, this chute should be closed at its head, the water would be thrown back, and would take its old direction, and the quantity would be much increased as well as the velocity and consequent scour, and thus, in a short time, the bar in front of the city would be washed away; and not only this, but also the bar 2 miles below the town, and the other obstructions of the same nature met with between the head and foot of Island No. 14 would be removed.

It is not proposed to raise the crest of the dam to more than 3 feet above low water, as only at the lower stages would its full action be desired.

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It will be seen, then, that this improvement would afford uninterrupted navigation at all stages through 4 miles of a badly-obstructed portion of the river, would be desirable on general grounds as being almost of national importance, and would be needed to give full effect to the improvement of the Des Moines Rapids, at present nearly completed under your charge, freeing, also, the city of Fort Madison from its sand-blockade.

I would most respectfully present the following project for the improvement of the Mississippi River at this locality:

First. The construction of a dam across the head of the Niota Chute, having its east end about 500 feet below the present ferry-landing, and running across to the head of Island No. 14, (location shown on map,) the shores at both ends to be protected by riprap. The proposed dam is 1,400 feet in length and 5 feet wide on top, with a slope of 1 to 1 on either side, and having its crest 3 feet above low-water mark. I would construct it chiefly of rock, (quarry refuse,) which can be very cheaply obtained from the Niota quarries or elsewhere. My plans include a foundation of brush, made into mats and fascines, about 2 feet in thickness, to be sunk, and the rock then thrown in until the dam is raised to the required height, the work to be aided and strengthened by rows of piling.

Second. The construction of a light dam from Island No. 14 to small island, to prevent a diversion of a portion of the water in this direction. (See map.) This should be of brush and earth, with a ballasting of rock similar to those now being built under your direction in the improvement of the Illinois River. This dam would be 420 feet in length, and some shore-protection would be needed.

Third. The excavation of a small ledge of rock directly in the track of the ferry-boat and of steamers landing on the Niota side.

The position of this rock is shown upon the map.

Fourth. The removal by dredging of the upper portion of the sand-bar in front of the city as well as cutting a channel through the narrowest portion of the bar. (Shown on map.) This will open up at once about 1,000 additional feet of levee for steamboats, and it is expected that the remainder of the bar will be soon scoured out, and the threatened insulation of the city averted.

ESTIMATE.

Dam across head of Niota Chute.

612 cords brush, (for foundation,) at $2.25	$1,377 00	
1,900 linear feet piling, (in position,) at 20 cents	380 00	
5,400 cubic yards rock, (body of dam,) at $2	10,800 00	
1,100 cubic yards riprap, (shore-protection,) at $2	2,200 00	
Labor, engineering, and contingencies	5,243 00	
		$20,000 00

Small dam.

336 cords brush, at $2.25	756 00	
160 cubic yards rock, at $2	320 00	
370 cubic yards earth, at 35 cents	129 50	
800 linear feet piling, at 20 cents	160 00	
400 cubic yards riprap, at $2	800 00	
Labor, engineering, &c., 25 per cent	541 37	
		2,706 87

Removing rock.

150 cubic yards rock-excavation, at $8	1,200 00	
Engineering and contingencies, 10 per cent	120 00	
		1,320 00

Dredging.

16,000 cubic yards sand, at 35 cents	5,600 00	
Engineering and contingencies, 10 per cent	560 00	
		6,160 00
Total		30,186 87

Or, in round numbers, $30,000.

It may be proper to add here a few statistics concerning the river-trade of Fort Madison and its commercial importance.

1st. The river is open to navigation from 8 to 9 months in the year. The regular steamboat arrivals are on an average about 4 per day, while a great many others touch here. All take coal at this point, going up stream, as they prefer passing the Des Moines Rapids light, and this is the first point above the rapids where coal is sold to any extent.

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2d. The 4 large mills here manufacture about 18,000,000 feet of lumber annually, besides an immense amount of shingles and laths. Their sales, together with those of the lumber-yards, amount to over 20,000,000 feet per annum, all of which is handled on the river-front, either in logs or manufactured—(rafts.)

3d. The State penitentiary is located here, and the convicts are employed in the manufacture of agricultural implements, furniture, and shoes. A large bulk of raw material is consumed by them, and shipments of goods made in the prison are forwarded almost daily by river to various points.

4th. The plow-works, wagon-factories, coopers, millers, and brewers receive large amounts of material by river for manufacturing purposes, and their various wares are in great part shipped by river.

5th. The pork business is becoming quite important, and the shipment of grapes and fruit is very large. In 1874 there were 20,000 barrels of apples shipped from Fort Madison by river.

6th. So soon as the improvement of the Des Moines Rapids is completed, the shipments, now going south by rail, will doubtless be changed to the river.

All of which is respectfully submitted.

Very respectfully, your most obedient servant,

C. W. DURHAM,
Assistant Engineer.

Colonel J. N. MACOMB,
Corps of Engineers, U. S. A.

N 6.

SURVEY OF HARBOR AT BURLINGTON, IOWA.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., December 6, 1875.

SIR: I beg leave to transmit herewith a report of Mr. C. W. Durham, assistant engineer, on the survey at Burlington, Iowa, made in August, 1875.

In my letter of February, 1875, transmitting a report of Mr. M. Meigs, assistant engineer, on an examination of this locality, I respectfully recommended a special appropriation of $1,000 for making a *detailed* survey, inasmuch as, the examination being made in the dead of winter, when the river was ice-bound and the weather very inclement, sufficient data could not be obtained for a proper consideration of the subject and for reliable estimates for improvement.

In your letter dated Office of the Chief of Engineers, Washington, D. C., April 20, 1875, I received instructions to make surveys of the obstructions in the Mississippi River at and near the cities of Burlington, Iowa, and Fort Madison, Iowa, and was informed of an allotment of $2,000 from the appropriation "for examinations, surveys, and contingencies of rivers and harbors" to enable me to make the surveys in question.

By letter of the 26th July, I instructed Mr. Durham, who was then conducting the survey of the "Upper Mississippi River route," to make special surveys at Burlington and Fort Madison on arriving in their neighborhood.

Mr. Durham states in his report that the sand-bar which has been forming for some years in front of the city of Burlington, and which in 1873 and 1874 had attained such proportions as to apparently endanger the commercial prosperity of the city, has, owing to certain changes in the direction of the river-currents, been cut through and scoured out to such an extent as to remove the obstructions to the approaches to the levee, and at present no reasons exist for apprehending a future insulation of the city.

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It further appears that the channel leading to the bridge-draw is exceptionally good, and that the bridge and draw are admirably located as regards the navigation of the river.

Mr. Durham calls special attention in his report to the serious obstacles to navigation existing at the head and foot of Rush Chute, a short distance above Burlington. These are two of the worst points on the Upper Mississippi, and the removal of the obstructions would be an incalculable benefit to the commerce of the Mississippi Valley and would furnish a clear river (some few comparatively unimportant exceptions being made) from Burlington to a point some 150 miles above. Mr. Durham presents a project for the improvement at head and foot of Rush Chute, in which he recommends the construction of 3 dams, the cost of which from his estimates would be in round numbers $35,000.

The proposed location of these dams is shown on the map accompanying his report.

I approve of the project set forth in the accompanying report of Assistant Engineer Durham, and would respectfully recommend that an appropriation be asked for with which to carry it out.

Respectfully submitted.

J. N. MACOMB,
Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. C. W. DURHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., November 30, 1875.

SIR: I have the honor to present herewith my report on the survey of a portion of the Mississippi River in the vicinity of Burlington, Iowa.

On the 26th July, I received instructions from you to the following effect: "In prosecuting the surveys for the improvement of the Mississippi River, you will, on reaching the vicinity of Burlington, Iowa, make a special survey from above that city to such point below it as you may find necessary to enable you to make a plan and estimate for the permanent improvement of the river in that vicinity, with a view to the more easy approach to the Burlington levee at all stages of the river."

In accordance with these instructions, I began the survey on the 29th July. In order to make the survey as complete as possible, and with a view to the improvement of *general* navigation, as well as the removal of the bar immediately in front of the town, I commenced work some distance above the head of Rush Chute and carried the survey down river to about 1,500 feet below the railroad-bridge. The survey embraces the main river, and also Rush Chute and O'Connell Slough, and sufficient transit and compass lines were run and triangulations made to give a complete outline of the main shores as well as of the numerous islands and sand-bars in which this portion of the river abounds. A line of levels was run down the left bank, a profile of which is shown upon the map. Numerous bench-marks were established and water-surfaces taken. From the water-gauge on the railroad-bridge I obtained the elevation of the river-surface at *low water*, and this elevation is used as a datum upon which my plan and estimates are based. Some 6,500 soundings were made, nearly all of which were located by theodolites, and these have been plotted as taken, and show the various depths at a stage of 1.5 feet above low water, which was the stage of the river during the sounding operations.

I have made my estimates for improvement to give 5 feet of water at *extreme low water*, which is the design followed in the improvement of the Des Moines Rapids. Contour-lines in *blue* have been drawn on the map showing the limits of the 5-foot channel at *low water*.

I made a gauge of Rush Chute at its foot, and also of O'Connell Slough.

As regards the steamboat-channel, in previous years it has been subject to frequent changes.

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Some seasons the best water has been found on the east side of Rush Island, and at other times boats have run Rush Chute.

In the former case navigation has been invariably bad, the channel being very crooked and shallow, and subject to sudden changes, sometimes several in one season. This is but a natural result from the immense width of water-way here presented, and the numerous small islands and sand-bars existing. When the steamboat-channel is in Rush Chute, very little difficulty is experienced, except at the head and foot of the chute.

O'Connell Slough affords a fine raft-channel, except at the lower stages of the river.

During the last eight or ten years a sand-bar has been gradually forming, beginning above town and gradually extending down river in front of the city. In the last few years, and up to the winter of 1874–'75, the growth of this bar was very rapid, and at that time it had extended down stream as far as Valley street. The dotted red line on the map shows the outline of the bar at its maximum.

Although it was situated nearly in the center of the river, leaving a wide and deep channel along the city front, fears were entertained that it would crowd over upon the town and block up the approaches to the levee.

Descending boats touching at Burlington were obliged to make a wide circuit around the foot of the bar and then come up inside to the landing, and ascending boats were compelled to make the same detour in the opposite direction. When the water was too low in O'Connell Slough, rafts were unable to make a landing until they reached the lower end of town. It may be added that there was no obstruction to *through* navigation at this point, that is, to boats not landing at Burlington, and the draw of the railroad-bridge is admirably located and in such a position that there will always be a sufficiency of water.

During the spring of 1875 changes in the channel occurred which caused a "cutting through" of the bar opposite the upper end of the city, and this passage has become wide and deep, so that, at the time of present writing, a good channel exists, and nearly all the lower portion of the bar has been washed away, and the approach to the levee is perfect.

I may also add that there is scarcely any probability that the city will ever suffer from the encroachment of sand to any extent, and that there will always be a deep channel in front of the levees kept open by the water from O'Connell Slough.

I trust it will be proper in this report to suggest the improvement of the river at the head and foot of Rush Chute. At these two points, just above Burlington, and included in the present survey, there are obstructions to *general* navigation of a very serious nature, and such that boats are often detained for hours, and sometimes days. The removal of these obstructions would open up the river for 150 miles above, except at a few points which will be mentioned in my report on the "Upper Mississippi River route," and where the difficulty is not so serious in its nature.

Thus it will be seen that the interests not only of Burlington but also of all the country and towns lying on this stretch of river demand the improvement in this locality. The larger towns in this division are Burlington, Oquawka, Keithsburgh, New Boston, Muscatine, Rock Island, Davenport, Clinton, Fulton, and Lyons.

Observation has shown us, in the case of the Upper Mississippi River, that a sand-bar is formed at the head and foot of nearly every island, and where the water is divided into two nearly equal parts there is often insufficient water in either, at low stages, to afford the requisite depth; or the natural slackening of the current in a great many cases permits the bar to extend entirely across the channel.

At the head of Rush Chute both of these circumstances come into play; bars have formed entirely across both channels, and there is not sufficient current in either to keep a deep passage open. The blue lines on the map show the outlines of the submerged bars, and the limits of the5-foot channels at low water, and an examination of these will show at once the entire situation. At the *foot* of Rush Chute the same difficulty is met with. No serious obstruction is experienced in the chute itself.

In accordance with the above, I would most respectfully recommend the following project for improvement, which, if carried out, will afford a wide and deep channel for all time at all stages of the river, and not only open the approach to Burlington, but remove the only really serious difficulties now existing between that city and a point nearly 150 miles above.

First. A dam of stone and brush across the main river from Otter Island to the head of Rush Island. This will turn the water down Rush Chute and keep the steamboat-channel where it now is.

The reasons for navigating Rush Chute in preference to the main river are obvious. It is sufficiently wide, more protected from winds, and is the most direct route.

Should the water be turned down the east side of Rush Island, it would spread over a very wide section of river, and would split up into various channels among the numerous islands and bars, and no benefit could be assured; whereas in Rush Chute the water-way is more contracted, the banks are tolerably high and stable, and the increased

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current and volume of water would clear out all obstacles now existing, and insure a sufficient depth at all times.

The proposed dam is 1,400 feet in length, principally built of rock, and with a foundation of brush 2 feet in thickness, and strengthened by piling. The crest should be about 3 feet above low-water mark, and I have estimated for a 5-foot width on top and a slope of 1 to 1.

The roots of the dam and the adjacent shores would have to be protected by riprapping, as well as a portion of the bank on the west side of Rush Chute, where the current would impinge.

The dam would have full effect only at the lower stages of the river, its crest being but 3 feet above *low water*, so that no danger would be experienced from floods, and sufficient water would be obtained at the time when most needed.

The proposed location of the dam is shown on the map.

Second. I would also recommend the construction of a light subsidiary dam of brush, to close up the small island chute nearly in the center of Rush Chute. This would be about 400 feet in length, and could be very cheaply built on the Illinois River plan. It would straighten the channel somewhat and prevent a diversion of a portion of the water around the small island.

(For location see map.)

Third. To complete the system, a light brush dam should be built from O'Connell Island across to the head of small island at the foot of Rush Chute. This dam would be 800 feet in length, and would prevent a diversion of the water at this point.

(For location see map.)

All the material for these dams can be obtained at a cheap rate in the immediate vicinity.

ESTIMATE FOR IMPROVEMENT OF MISSISSIPPI RIVER IN VICINITY OF BURLINGTON, IOWA.

Dam No. 1.

From Otter to Rush Island, including shore-protection on west side of Rush Chute:

784 cords brush, (foundation,) at $2.25	$1,764 00	
2,375 linear feet piling, (in position,) at 20 cents	475 00	
7,500 cubic yards rock, (body of dam,) at $2	15,000 00	
2,000 cubic yards riprap, (shore protection,) at $2	4,000 00	
Labor, engineering, and contingencies, 30 per cent	6,371 70	
		$27,610 70

Dam No. 2.

In Rush Chute:

320 cords brush, at $2.25	720 00	
148 cubic yards rock, at $2	296 00	
352 cubic yards earth, at 35 cents	123 20	
800 linear feet piling, at 20 cents	160 00	
500 cubic yards riprap, at $2	1,000 00	
Labor, engineering, and contingencies, 25 per cent	574 80	
		2,874 00

Dam No. 3.

Foot of Rush Chute:

488 cords brush, at $2.25	1,098 00	
266 cubic yards rock, at $2	532 00	
496 cubic yards earth, at 35 cents	173 60	
1,600 linear feet piling, at 20 cents	320 00	
833 cubic yards riprap, at $2	1,666 00	
Labor, engineering, and contingencies, 25 per cent	947 40	
		4,737 00
Total		35,221 70

Or, in round numbers, $35,000.

I will add a few facts concerning the commercial importance of Burlington. The chief river-trade is in lumber, in which about one thousand men are employed, and this business constitutes the chief element of the prosperity of the city. During the season of 1874 there landed at the levee 476 steamboats, exclusive of barges, representing 285,000 tons of tonnage, and putting on shore or receiving 11,400 tons of freight and 4,350 passengers.

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The following statement shows the amount and value of various articles handled on the river-front in 1874:

Designation.	Value.
Lumber, logs, &c., 95,000,000 feet	$1,615,000 00
Shingles, 68,000,000	187,000 00
Lath, 10,000,000	25,000 00
Pickets, 2,000,000 feet	6,000 00
Sash, doors, &c	50,000 00
Wood, 8,000 cords	32,000 00
Coal, 12,000 tons	36,000 00
Brick, 300,000	2,400 00
Sand, 2,000 tons	800 00
General merchandise, 75,000 packages, or about 12,000 tons	1,263,680 00
Total	3,217,880 00

In addition to the above, large amounts of grain, hogs, fruit, hay, and vegetables, no estimate of which can be given, were received or shipped by river.

All of which is respectfully submitted.

Very respectfully, your most obedient servant,

C. W. DURHAM,
Assistant Engineer

Colonel J. N. MACOMB,
Corps of Engineers, U. S. A.

N 7.

EXAMINATION OF DUBUQUE HARBOR, IOWA.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., March 14, 1876.

SIR: I have the honor to transmit herewith a report of assistant engineer C. W. Durham on an examination of the harbor of Dubuque, Iowa.

In accordance with your letter dated Washington, D. C., January 5, 1876, containing instructions for an early examination of the above-named locality, and allotting the sum of $200 for that purpose from the appropriation for examinations and surveys on Western and Northwestern rivers, I instructed Mr. Durham to proceed to Dubuque as soon as the weather would permit, and make an examination of the harbor of that city, with a view of proposing a remedy for the existing and threatened impediments to navigation, and furnishing an estimate of the cost. Mr. Durham presents in his report a voluntary statement of a number of well-known citizens, which is, I think, worthy of notice. The bar in front of Dubuque has been, during a number of years, a great obstruction, and threatens to become even more troublesome. The causes which led to its formation are well known and fully set forth in the accompanying report. I approve of Mr. Durham's method of improvement, and would most respectfully recommend an appropriation of $32,000 for carrying out the plans indicated.

Very respectfully, your obedient servant,

J. N. MACOMB,
Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

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REPORT OF MR. C. W. DURHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., February 1, 1876.

SIR: I have the honor to present a report on an examination of the harbor of Dubuque, Iowa, conducted by me during the month of January, 1876.

Accompanying this report is a map, containing a large number of soundings made in the course of my examination, and others obtained from the city engineer.

All of the soundings are reduced to *low water of* 1864. On the same sheet are: A sketch of the vicinity of Dubuque, compiled from General Warren's map of 1866, with such changes as have occurred since that time; a profile of the center line of the proposed cut-off, and sections of Seventh-street slough, and New Barney cut, on the lines of proposed dams. All of the above drawings were executed by Mr. F. S. Eastman, assistant engineer.

On the 8th of January, I received orders from you to proceed to Dubuque as soon as the weather would permit, for the purpose of ascertaining the danger of filling up, which threatens the harbor of that city; of suggesting a remedy for the existing and threatened difficulties; and of presenting an estimate of the cost of averting them. On arriving at Dubuque, I called on the city engineeer, and the engineer of the "ponton-bridge company," and obtained from them various data in regard to old harbor-lines, &c. I was also able to make a tolerably thorough survey of the locality myself. During my stay in the city, a number of the oldest, wealthiest, and most reliable citizens of Dubuque waited upon me and presented me with a statement, of which the following is a true copy.

STATEMENT OF CITIZENS OF DUBUQUE.

"We, the undersigned citizens and old residents of Northern Iowa, on the banks of the Mississippi River in the vicinity of Dubuque, being familiar with the location of the main steamboat-channel as it existed in the last thirty years and as it now exists, and with the formation of sand-bars affecting the same, are convinced that the sand-bar now existing and yearly increasing in the river opposite the public landing of Dubuque has become a great impediment to the navigation of the river, and consequenaly a burden or taxation on the commerce of the country tributary to the river north of this latitude, inasmuch as steamboats and rafts of logs and lumber are already subjected to great inconvenience in crossing or getting around the bar, also in reaching a safe landing on the west bank of the river at the public landing; and unless some means are soon adopted to remove this bar, the navigation across it at *low* or even *medium* stages of water will be wholly obstructed."

(Signed by Richard Bonson, and 15 others.)

From the above, from examination of old maps, and from the present survey, it appears that some twenty years ago, and prior to that time, the main steamboat channel ran along the west bank of the river, so that boats could effect a landing at all stages of the river along the entire city front, from Seventh-street slough to the elevator. Boats and rafts also made use of the channel through Lake Peosta, and landed at what is now called Old Landing. Since that time a bar has been gradually forming, beginning at the mouth of Seventh-street slough and enveloping the entire city front, leaving only a very narrow channel between its lower end and the lower part of the levee. Until the last few years, boats were able to work up to the lower levee, passing around the foot of the bar, and making a wide circuit, if coming down river. The opening being so narrow that boats could not turn, they were obliged to back out nearly a half mile, a difficult and tedious proceeding, especially if encumbered by barges, as is generally the case. During the past season even this narrow channel was so obstructed that boats were unable to reach their landings, and our soundings now show a width of deep water-way of only about 150 feet; and even this passage, narrow as it is, would be blocked at low water to steamers drawing 4½ feet of water and over. Of course, when several boats are at the levee at the same time, the difficulties are aggravated, and the necessary wharf-boats still further limit the available space.

The ferry-boat plying between Dubuque and Dunleith experiences great difficulty every season in getting over or around the bar.

A comparison of the soundings taken by General Warren in 1866 with those made by me clearly shows that the bar is gradually closing in upon the shore at the lower levee, so that in a few years, unless something be done to avert the calamity, Dubuque will be entirely inaccessible to steamboats at low or even medium stages of the river. Rafts have been unable for years to effect a landing at Dubuque at low stages, and the lumber interest, which is a very large one, cries for relief.

The causes which have led to the formation of this bar, and the gradual closing up of the narrow passage before indicated, clearly appear. Some 20 years ago all the water passing through Lake Peosta, the two inlets of which are shown in the sketch, passed out into the main river through Waple's Cut, and the current from this passage

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kept the *lower* levee free from obstruction; nor was there at that time any impediment to the landing at the *upper* levee between what is now called Seventh-street Slough and Waple's Cut. In the winter of 1858–'59 two lateral breaks occurred, one at Seventh street and the other somewhat lower down, and called the New Barney Cut. The current from these two breaks, which now diverts by far the greater portion of the water passing through Lake Peosta, meeting that of the main river nearly at right angles, has caused the formation of a sand-bar, enveloping the entire city front. The extension of Third street still further limited the amount of water passing through Waple's Cut, so that this outlet, formerly navigable to steamboats, and offering a safe winter harbor, is now almost entirely filled up.

The remedy which I propose for removing the obstructions is explained below, and I may add that I am supported in my explanations of the causes which led to the present state of affairs as well as in my plans for improvement by the united opinions of all those whom I have consulted—men who have resided here for many years, are conversant with the various changes of the river, and experienced in all that relates to the river navigation.

I trust that, by eliminating the causes which led to the obstructions, the old régime may be restored. My plan is:

1. To make an artificial cut-off from the head of New Barney Cut to the mouth of Waple's Cut (location shown on map) in such a manner that the current from the new channel may be directed along the lower levee and parallel to it. The effect of this current will be to widen the passage now existing between the bar and the shore, and to gradually remove the lower end of the bar from the mouth of Waple's Cut to the elevator. The proposed cut-off will be 150 feet wide on bottom, with a slope of 2 to 1 on the sides, and its grade the *low water* of 1864. The water, once started through the new channel, will deepen and widen the passage sufficiently to accommodate itself.

2. A dam (No. 1) across head of Seventh-street Slough, (location shown on map.) The proposed dam is 600 feet in length, principally constructed of rock, and with a foundation of brush 2 feet in thickness, strengthened by two rows of piling, the piles being 10 feet apart longitudinally. The crest should be about 4 feet above low-water mark, and I have estimated for a 5-foot width on top and a slope of 1 to 1. The roots of the dam and the adjacent shores will be protected by riprapping.

3. A dam (No. 2) across mouth of New Barney Cut, (location shown on map,) of similar construction to the one above described. This dam will be about 400 feet long.

4. A dam (No. 3) across the Third-street opening, (location shown on map.) No brush foundation will be needed here, as the opening has been partially closed with rock.

All the material for these dams can be obtained at a cheap rate in the immediate vicinity. The land through which the cut-off is located mainly belongs to the city, which will doubtless give the necessary authority for undertaking the work and secure the Government against all claims for damages.

ESTIMATE.

Cut-off.

73,640 cubic yards earth excavation, at 25 cents		$18,410 00

Dam No. 1.

Seventh-street Slough:		
220 cords brush, (foundation,) at $2.25	$495 00	
2,409 linear feet piling, (in position,) at 20 cents	480 00	
1,120 cubic yards rock, (body of dam,) at $2	2,240 00	
555 cubic yards riprap, (shore protection,) at $2	1,110 00	
		4,325 00

Dam No. 2.

New Barney Cut:		
140 cords brush, (foundation,) at $2.25	315 00	
1,600 linear feet piling, (in position,) at 20 cents	320 00	
820 cubic yards rock, (body of dam,) at $2	1,640 00	
277 cubic yards riprap, (shore protection,) at $2	554 00	
		2,829 00

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Dam No. 3.

Third-street opening:		
160 linear feet piling, (in position,) at 20 cents	32 00	
50 cubic yards rock, at $2	100 00	
		132 00
		25,696 00
Labor, engineering and contingencies, 25 per cent		6,424 00
		32,120 00

Or, in round numbers, $32,000.

All of which is respectfully submitted.

Very respectfully, your most obedient servant,

C. W. DURHAM,
Assistant Engineer.

Col. J. M. MACOMB,
Corps of Engineers, U. S. A.

APPENDIX O.

ANNUAL REPORT OF MAJOR F. U. FARQUHAR, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., July 7, 1876.

GENERAL: I have the honor to transmit herewith my annual reports of operations at the several works under my charge during the year ending June 30, 1876.

Very respectfully, your obedient servant,

F. U. FARQUHAR,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

O 1.

PRESERVATION OF THE FALLS OF SAINT ANTHONY, MISSISSIPPI RIVER.

During the year the entire excavation for the concrete dike was made and the dike itself completed, except the filling of the upper and lower passages. Eight thousand three hundred and seventy-seven cubic yards of concrete were put in place, making a total now in place of 11,484 cubic yards. There only remains about 3,000 cubic yards of concrete to be put in place to complete this portion of the work.

The average cost per cubic yard of concrete in place was, during the year, including excavation, pumping, and all the contingencies of the work, only $11.31; for the previous year the average cost was $28.68 per yard of dike in place, but this year the work was troubled but with one (August 1, 1875) serious incursion of sand and water.

The apron was repaired and cost $25,215.46, of which amount $1,500 were contributed by the citizens of Minneapolis. On making soundings at the foot of the apron preparatory to commencing the repairs, it was found that at the foot of the apron on the east side the sand-rock was eroded to a depth of 42 feet below water.

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The concentration of the whole volume of the Mississippi River into a width of not more than 200 feet, as is done by the faulty construction of the Water-Power Company's dams and the apron itself, makes it necessary to expend constantly sums of money to repair the apron, as nothing short of a granite-lined channel below the falls would resist the eroding effect of the immense volume of water that at seasons of high-water pass over.

The proprietors of the Minneapolis Water-Power Company have consented to remove the saw-mills on the platform extending into the river from the west bank as soon as the leases expire, and they have already commenced to take up the expired leases when such leases provided for an extension or valuation of improvements.

When these mills are removed an additional water-way of 200 feet will be gained, which of course will materially diminish the amount passing over the apron. I am of the opinion that the Saint Anthony Water-Power Company should also arrange their dam on the east side of Hennepin Island, so that at seasons of high water a portion of the discharge of the river should pass over that portion of the falls below their dam.

Should Congress provide the necessary funds, the following work will be carried out during the fiscal year ending June 30, 1877:

1. The dike will be completed;
2. The rolling-dams on the ledge above the falls in the main channel will be built;
3. The excavations under the limestone above the dike will be filled with gravel; and
4. An extension of the apron will be constructed on the east side of the main channel.

The proposals for the second and third items have already been opened, and contracts will be awarded as soon as funds are appropriated.

The original estimate for the preservation of the Falls of Saint Anthony was as follows, (see page 285, Part I, Report of the Chief of Engineers, 1874:)

For construction of dike	$130,372 00
For completion and repairs of apron	65,000 00
For dams on limestone	24,420 00
For wall at head of ledge	200,000 00
	419,792 00

There have been appropriated as follows:

By act approved June 23, 1874	$125,000 00
By act approved March 3, 1875	100,000 00
	225,000 00

There have been expended as follows:

Construction of dike	$183,780 28
Repairs of apron	23,715 46
Repair of coffer-dams and work necessary to repair damages made by river	16,707 60
	224,203 34

The estimated cost to complete the dike is $28,501.77, making the total cost of dike $212,282.05, or $81,910.05 more than estimated. But the original estimate was for 11,852 cubic yards of wall, at $11 per yard, but owing to the changes of dimensions made necessary by the character of the rock and the danger from constant incursions of the water, the actual contents of the finished dike will be 14,484 cubic yards, and the cost per cubic yard will be $14.66.

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The estimate for the completion of work as proposed by the Board of Engineers 1874, will be as follows:

For completion of dike	$28,501 77
For repairs and extension of apron	41,284 54
For dams on limestone ledge	24,420 00
For wall at head of ledge	200,000 00
	294,226 31
Add for filling excavations under limestone ledge and above dike with 21,000 cubic yards of gravel, at 50 cents per cubic yard	10,500 00
	304,726 31
Amount already appropriated	225,000 00
Total cost	529,726 31

I think the amount ($125,000) asked for in my last annual report for the present year will be sufficient to finish all the work at the Falls of Saint Anthony, recommended by the Board of Engineers 1874, except the upper wall. I would suggest that the effect of the one now being constructed be observed, and I hope that it may prove adequate to stop the percolation without any other wall or dike being built above it.

The following is a copy of the detailed report of Assistant Engineer J. L. Gillespie, who has had local charge of the works. Great credit is due Mr. Gillespie for his great intelligence and energy in carrying on the work.

REPORT OF MR. J. L. GILLESPIE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., June 30, 1876.

SIR: I have the honor to make the following report of the progress of the works for the preservation of the Falls of Saint Anthony during the year ending June 30, 1876:

THE CONCRETE DIKE.

At the close of the last fiscal year the foundation of the dike was laid for a distance of 479.6 feet, and the dike completed to the upper level for 450.8 feet, 130.3 feet east and 320.5 feet west of the main shaft on Hennepin Island. The upper drifts had been excavated 356.8 feet eastward and 405 feet westward.

On July 8 a spring was struck at the west heading, 370 feet from the shaft and 30 feet below the ledge, which increased rapidly for a few hours, bringing in sufficient sand to fill the lower drift west of the first sump. The increased flow at this time was due to the stoppage of the drain in the east passage, (break of April, 1875,) the water from that point finding its way through seams in the sand-rock to the west heading. The drain was re-opened, reducing the flow of the spring, which was then confined to a 6-inch pipe, the cavity formed by it being filled with concrete. During the remainder of the month the spring continued to flow steadily, frequently bringing in large quantities of sand and seriously delaying the progress of the work. On August 1 the spring again increased in volume, bringing in such quantities of sand as to fill the lower drift nearly to the top of the arch. This time it was found that the drain in the west passage (break of 1873) had been closed by the fall of a mass of sand-rock and shale, and the water from this channel, together with a small stream from the first break, was draining into the west drift instead of the old tunnel, as heretofore. Two days later the pumps, driven by water-power, were disabled by the breaking of the driving-shaft, and the Heald & Sisco steam-pump, after running a few hours, was also broken, allowing the excavation to fill with water nearly to the level of the upper drifts before the damage could be repaired and a jury-pump started. This, together with the spring above mentioned, caused the sand-rock at the west heading to cave down, forming a channel from 10 to 15 feet wide, extending northward from the dike about 100 feet. From the 5th to the 23d of August work on the dike was confined to clearing out the sand which had accumulated in the pump-well and lower drifts.

In the mean time the channel from the break of 1873 was re-opened and cleared out to the head of the drain-pipe, a drift cut through the sand-rock from this channel to the first break, and pipes laid to convey all drainage-water to the iron pipe in the main tunnel.

This work reduced the flow of the spring at the west heading to about one-half the capacity of the 6-inch pipe through which it flows, and put an end to the incursions of

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sand. The spring continued in the same condition up to the time of stopping the pumps, March 31, 1876.

From August last to the stoppage of the work this spring the construction of the dike continued steadily without serious interruption. The quantity of water met with in the excavation was comparatively small, and the streams easily controlled. The excavation for the east branch of the dike, 600 feet in length, extending 70 feet east of high-water shore-line, was finished in November. The side-walls of the lower drift were continued to the end, but over the last 116 feet no arch was turned, the concrete filling being continuous from the bottom to the top. At the east end of the dike a cross-wall was constructed, forming a T with the main wall, the arms being each 6 feet by 3 feet. At 25 and 50 feet from the end, spur-walls were built, on the upper side of the dike, of similar dimensions. The upper east drift has been filled with concrete to within 127 feet of the shaft, the lower to within 170 feet. In filling the lower drift much trouble was experienced in stopping the flow of water at various points through the bottom and side walls, but at the time of stopping work the water had been almost entirely excluded.

The excavation for the west branch of the dike was completed March 7, and the concrete finished to the level of the upper drift March 14, at which latter date work was suspended, the appropriation being nearly exhausted. The last 35 feet of the dike was built up solid from the bottom, and cross and spur walls built similar to those at the east end. The length of the west branch of the dike is 1,275 feet, a reduction of 50 feet from the original plan, the firm character of the sand-rock seeming to render any further extensions unnecessary. The west end of the dike is 25 feet west of the river-shore line.

At a point 403.6 feet west of the intersection of drifts at the pump-well, the axis of the dike deflects 44° 38′ 32″ toward the south, the angle being turned on a curve of 48 feet radius. The side-walls on the north side of the upper west drift have been extended to a point 594 feet from intersection of drifts; that on the south side 315 feet.

The west branch of the tunnel, just above the crossing of the dike, has been closed by a bulk-head of concrete. Three pipes, 12 inches in diameter, are laid through the concrete to carry off the drainage from the upper tunnel. The pumps were kept running until the evening of March 31, when they were stopped, and the lower drifts allowed to fill with water. The water rose slowly until it reached the discharge-pipe leading from the pump-well to the west branch of the old tunnel, where it has remained stationary, discharging through the pipe at the rate of about 10 gallons per minute.

The general plan of construction pursued has been the same as described in the last annual report, the main variations being the substitution of an open box-drain for the stone pipe formerly used in the foundation, and the use of hoisting-engines for raising the excavated sand on inclined planes from the lower to the upper drifts. In November last a Blake steam-pump was placed in the pump-well, which has rendered efficient service whenever the pumps driven by water-power have been stopped for repairs.

During the summer and fall of 1875, the ledge covering the channel from the first break on the west side of Nicollet Island was quarried out, the stone being used in the construction of the dike, and the channel filled with gravel as the quarrying progressed. Since November last the stone for the dike has been obtained from the lower part of Hennepin Island, near the original entrance to the tunnel. The amount of concrete put in during the year is 8,377 cubic yards, making, with 3,107 cubic yards put in last year, a total of 11,484 yards now in place in the dike. The average cost per yard of finished wall during the year has been $11.31. Average cost last year, $28.68. Average for the two years, $16.

The amount of sand excavated during the year was 9,324 cubic yards. The total amount of measured excavation to date has been 13,361 yards, to which should be added cavities not measured, estimated at 850 yards.

There remains to complete the dike, the filling of the upper and lower drifts, pump-well, and sumps, which will require about 3,000 yards of concrete.

REPAIR OF THE APRON.

Early in August the work of repairing the apron at the face of the falls was commenced, the lower end of this structure having been entirely destroyed by the ice-freshet in the spring of 1875, and the bottom of the river below scoured out to a depth of 30 to 40 feet. Large timber-cribs filled with stone were sunk at the foot of the apron, upon which the plank covering was extended, with the same slope as above, to a depth of 2 feet below low water. A large amount of stone was also put in below the cribs. The original planking was renewed wherever necessary, the 4-inch pine covering extended over the east half, which had been left unfinished, and the more exposed portions protected with oak planking.

Work was continued until December, when it was suspended on account of the severe cold, the repairs being then completed with the exception of leveling and covering a

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length of 140 feet at the foot on the west side. This portion of the work was finished during the month of March, funds ($1,500) for the purpose having been furnished by the citizens of Minneapolis.

There has been expended on the apron during the year by the United States Government	$23,715 46
By the citizens of Minneapolis	1,500 00
Total	25,215 46

The foot of the apron on the west side has again settled somewhat and will need further repairs, the extent of which cannot be determined until the season of low water. So long as the abrading action of the water passing over the falls is confined to its present narrow limits, the apron cannot be made permanent and will require constant repairs.

Very respectfully, your obedient servant,

J. L. GILLESPIE,
Assistant Engineer.

Major F. U. FARQUHAR,
Corps of Engineers, U. S. A.

Money statement.

Amount available July 1, 1875	$135,106 76
Amount expended during fiscal year ending June 30, 1876	132,044 38
Amount available July 1, 1876, including $511.70 due on contracts	3,062 38
Amount appropriated by act approved August 14, 1876	120,000 00
Amount (estimated) required for completion of existing project	184,726 35
Amount that can be profitably expended in fiscal year ending June 30, 1878	5,000 00

O 2.

IMPROVEMENT OF THE MISSISSIPPI RIVER ABOVE THE FALLS OF SAINT ANTHONY.

No work of improvement was carried on during the fiscal year, as the amount available from the appropriation made in 1874 was not enough to work on, and it was deemed necessary to expend the total sum appropriated by the act approved March 3, 1875, on the work at the Falls of Saint Anthony.

The river was thoroughly gauged for the purpose of determining the high and low water discharges. The localities at which the measurements were made and the amounts discharged were as follows:

Locality.	June 6 to 12. High water; cubic feet per second.	August 19 to 27. Low water; cubic feet per second.
Brainerd	15,220	2,450
One mile above Sauk Rapids	31,450	3,780
Fridley's Bar, 4 miles above Falls of Saint Anthony	42,500	4,500

I purpose making a special report on the subject of this gauging as soon as some additional data are collected, which will be as soon as work is resumed on the river.

There was no use made of the river between Minneapolis and Aitkin last season for any purposes of commerce except the running of logs. Between Aitkin and Grand Rapids one small steamer made as many

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trips as were necessary to supply the lumber-camps. A very small steamboat was put on the river above Minneapolis this spring, but I have not heard of its doing any business.

No amount additional to that ($75,000) asked for in my last annual report is necessary. Should that amount, or any other, be appropriated, it will be used in building wing-dams, commencing just below the Thousand Islands and continuing down stream, and removing bowlders from the bed of the river.

Money statement.

Amount appropriated by act approved August 14, 1876	$20,000 00
Amount (estimated) required for completion of existing project	55,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878.	55,000 00

O 3.

CONSTRUCTION OF LOCK AND DAM ON MISSISSIPPI RIVER AT MEEKER'S ISLAND, MINNESOTA.

No work has been done here, as no funds were available, because the parties holding the land-grant have not made any acceptable release as required by the act approved March 3, 1875. The State of Minnesota should annul the grant to the parties now holding the land-grant, and release the same to the United States.

Should it be determined to carry on this work, a sum not less than $300,000 should be appropriated for the fiscal year ending June 30, 1878.

Money statement.

Amount available July 1, 1876	$25 000 00
Amount (estimated) required for the completion of existing project	922,121 46

O 4.

IMPROVING MINNESOTA RIVER.

After due advertising, a contract was made, September 7, 1875, with Fendall G. Winston for removing snags, bowlders, and overhanging trees from the river and its banks. Under this contract all the snags and bowlders in the low-water channel and the overhanging trees on the banks of the river were removed between Mankato and a point 20 miles below.

The contractor made use of dynamite in loosening and destroying snags when they were so firmly imbedded in the bottom as to be beyond the power of his machinery to lift them.

The following is the summary of the work:

Overhanging trees cut down	1,9?2
Snags removed	1,319
Bowlders removed, cubic yards	?

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The estimate made for removing the snags, overhanging trees, &c., (see Annual Report Chief of Engineers, 1875, Part I, page 364,) was as follows:

3,335 snags, at $5	$16,675 00
24 drift-piles, at $100	2,400 00
4,122 fallen and overhanging trees, at $3	12,366 00
	31,441 00
10 per cent. for contingencies	3,144 10
	34,585 10
Appropriated by act approved March 3, 1875	10,000 00
Remaining to be appropriated	24,585 10

But since making the survey upon which the above estimate was made, many trees then on the banks have, owing to the undermining of the banks, become snags. Each year new obstructions are added by the caving in of the banks, and the results of improving the river by only removing these obstructions are only very temporary, and, were all the snags or other obstructions removed from the low-water channel, still, during low water, there would not be a sufficient channel for purposes of navigation.

Two small steamboats that went up the Minnesota River in May last during the high water had to discharge their return freights at Mankato before they could return to the Mississippi River, and even then they experienced great difficulty.

Between Mankato and Hurricane Bend there were removed during the fiscal year ending June 30, 1868, (see page 349, Report of Chief of Engineers, 1868,) 1,890 snags, and during past year 306 snags.

Until the lock and dam are built at Little Rapids there can be no navigation on the river above that obstruction except by flat-boats coming down stream, and even then they cannot pass the rapids at low water. I do not think any money ought to be spent for improving the river above Little Rapids until the proposed lock and dam at that locality is completed.

The detailed estimate of the cost of this lock and dam is as follows, (see page 363, Part I, Report of the Chief of Engineers, 1875:)

2,522 cubic yards rock-excavation, at $2	$5,044 00
5,113 cubic yards earth-excavation, at 50 cents	2,556 50
1,161 cubic yards hammered masonry, at $25	29,025 00
182 cubic yards rubble-masonry, at $12	2,184 00
5,050 cubic yards concrete, at $8	40,400 00
666 cubic yards earth-filling of hollow walls, at $1	666 00
2 sets iron gates and fixtures, at $5,000	10,000 00
300 feet needle-dam superstructure, at $70	21,000 00
500 feet coffer-dam, at $10	5,000 00
	115,875 50
10 per cent. for contingencies	11,587 55
	127,463 05

Should Congress make an appropriation sufficient to commence the lock and dam at Little Rapids, and in time to make use of the low-water season of 1876, work could begin as soon as contracts could be made, and it is probable that the foundations could be put in during the fiscal year ending June 30, 1877. Should only the usual appropriation of $10,000 be made, it might not be expended until next season, when, with an additional appropriation of $50,000, work might be commenced; or

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it could be used in continuing the removal of the snags and bowlders, &c., below the point reached last February.

Money statement.

Amount available July 1, 1875	$9,620 84
Amount expended during fiscal year ending June 30, 1876	9,577 38
Amount available July 1, 1876, including $29.02 due on labor and materials.	43 46
Amount appropriated by act approved August 14, 1876	10,000 00
Amount (estimated) required for completion of existing project, lock and dam at Little Rapids	127,463 05
Amount that can be profitably expended in fiscal year ending June 30, 1878, lock and dam at Little Rapids	60,000 00

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Abstract of proposals for removing snags, &c., from the Minnesota River, opened 12 m., August 27, 1875, by Maj. F. U. Farquhar, Corps of Engineers, United States Army, at Saint Paul, Minn.

Name and residence of bidders.	For removing bowlders.	For removing overhanging trees from the banks, of the following dimensions, measured 1 foot above the roots.				
	100 cubic yards.	48 trees, 36″ to 42″.	145 trees, 30″ to 36″.	418 trees, 20″ to 30″.	257 trees, 6″ to 20″.	132 trees, 4″ to 6″.
Sanford A. Hooper, Belle Plaine, Scott County, Minn.	$3 per cubic yard, $300 ..	$4 each, $192	$3 each, $435	$2.50 each, $1,045	$1.50 each, $385.....	75 cents each, $99....
Fendall G. Winston, Minneapolis, Minn	50 cts. per cubic yard, $50	$2.60 each, $124.80 ...	$2.42½ each, $351.62 ..	$2.25 each, $940.50 ...	$1.72½ each, $143.32 ..	$1.02½ each, $135.30 ..
Jos. Thornton, Saint Paul, Minn	$1.25 per cubic yard, $125	$2.75 each, $132.....	$2.60 each, $377.....	....do	$1.25 each, $321.25 ...	50 cents each, $66....
R. R. Dodge, Volney, N. Y	25 cts. per cubic yard, $25	$1 each, $48	$1 each, $145	$3.25 each, $1,358.50..	$2.25 each, $578 25 ...	50 cents each, $66....
Angus McDougall, Minneapolis, Minn	$5 per cubic yard, $500 ..	$3 each, $144.....	$2.50 each, $362.50 ...	$2 each, $836.....	$1.50 each, $385.50 ...	50 cents each, $66....
C. H. Lord, Shakopee, Minn	$5 per cubic yard, $500 ..	$6 each, $288	$4.50 each, $652.50 ...	$3.50 each, $1,463	$2 each, $514	$1 each, $132 .....

Name and residence of bidders.	For removing snags, logs, stumps, and trees with roots imbedded in the bottom of the river, of the following dimensions, measured 2 feet above the roots.					Aggregate.
	74 snags, 36″ to 42″.	184 snags, 30″ to 36″.	365 snags, 20″ to 30″.	262 snags, 6″ to 20″.	115 snags, 4″ to 6″.	
Sanford A. Hooper, Belle Plaine, Scott County, Minn.	$11 each, $814	$7.50 each, $1,380	$6.50 each, $2,372.50..	$5 each, $1,310.....	$1.25 each, $143.75 ...	$8, 476 75
Fendall G. Winston, Minneapolis, Minn.....	$8.20 each, $606.80 ...	$6.10 each, $1,122.40..	$4.70 each, $1,715.50..	$4 each, $1,048.....	$1.90 each, $218.50 ...	6, 756 74
Jos. Thornton, Saint Paul, Minn.....	$12 each, $888	$9.50 each, $1,748	$8 each, $2,920.....	$4.50 each, $1,179	$1 each, $115	8, 811 75
R. R. Dodge, Volney, N. Y	$10 each, $740	$7.50 each, $1,380	$5.25 each, $1,916.25..	$4.50 each, $1,179	$1.50 each, $172.50 ...	7, 608 50
Angus McDougall, Minneapolis, Minn	$13 each, $962	$10 each, $1,840.....	$8 each, $2,920.....	$6 each, $1,572	$1.50 each, $172.50 ..	9, 760 50
C. H. Lord, Shakopee, Minn	$18 each, $1,332.....	$12 each, $2,208.....	$9 each, $3,285.....	$6.50 each, $1,703	$1.50 each, $172.50 ...	*12, 250 00

*Informal; no seals attached.

Contract awarded to Fendall G. Winston, Minneapolis, Minn.

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O 5.

SURVEY OF THE CHIPPEWA RIVER, WISCONSIN.

UNITED STATES ENGINEER OFFICE,
Saint Paul, December 13, 1875.

GENERAL: I have the honor to make the following report of the results of a survey made during the past season on the Chippewa River, Wisconsin.

As the amount allotted ($1,800) for this survey was so small, it was thought best to use it in making detailed surveys of the worst obstructions below Chippewa Falls, as shown by the examination made in 1874. The results of this latter examination were reported by me in letter dated January 30, 1875.

Detailed surveys were made at the following localities:

1. Upper Dalles. (See accompanying tracing No. 1.)
2. Lower Dalles. (See accompanying tracing No. 2.)
3. Rumsey's Bar. (See accompanying tracing No. 3.)
4. Durand Bars. (See accompanying tracing No. 4.)
5. Head of Beef Slough. (See accompanying tracing No. 5.)
6. Mouth of river. (See accompanying tracing No. 6.)

1. UPPER DALLES.

This obstruction in the river is a little more than 4 miles below Chippewa Falls. The river here breaks through a ledge of coarse yellowish sandstone. The distance from the head to the foot of the Dalles is about 12,000 feet, and the total fall is 10½ feet, or an average of 4.62 feet per mile. By examining tracing No. 1, it will be seen that the only way to improve this part of the river for steamboat-navigation is by building a lock and dam. The lock-chamber should be 200 feet by 50 feet, with a lift of 10½ feet, and should be of stone and concrete masonry. The dam should be of timber, and furnished with an adjustable timber-chute for the use of rafts. The cost of this improvement will be as follows:

Dam, 557 feet long	$61,733 69
Timber-chute	10,007 95
Lock	122,523 41
	194,265 05
Add 10 per cent. for contingencies	19,426 50
Total	213,691 55

2. LOWER DALLES. (SEE TRACING NO. 2.)

The rapids at this locality commence about one and one-fourth miles above the mouth of the Eau Claire River. The river here again breaks through a ledge of coarse sandstone, and has cut through it a very tortuous channel. From the head to the foot of the rapids the distance is 9,850 feet, and the total fall is 8.8 feet. Here it is proposed to overcome the obstruction by constructing a dam with timber-chute just below the railroad-bridge, a canal 3,610 feet long from the dam, on the left bank of the river, and at the end of the canal a lock 200 feet by 50 feet, and 9½ feet lift.

The canal will be 100 feet wide at the water-line and 4 feet deep. At the upper end of the canal will be guard-gates. The cost of this improvement will be as follows:

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Dam, 570 feet long	$36,215 94
Timber-chute	8,246 76
Canal and locks	178,160 27
	222,625 97
Add 10 per cent. for contingencies	22,262 59
Total	244,888 56

3. RUMSEY'S BAR—4. DURAND BARS.

These places in the river are filled with sand-bars, the material for which has evidently been largely furnished by the high sand-banks just above them. I do not think there would be any difficulty in maintaining a good channel through these parts and others were the supply of sand cut off, and unless these "yellow banks" are protected from the erosive action of the river, any wing-dams or other constructions to improve the natural channel of the river will only have a very temporary effect.

There are on the river six of these "yellow banks," varying from 80 feet to 100 feet in height, and having a total of face exposed to the river of 21,000 feet. The river slopes of these banks are from 35° to 40°, and the sand can be seen continually rolling and sliding into the river. I think that, before any other work is commenced on the Chippewa River, the bottoms of these slopes should be protected. This protection should be of brush, made into fascines, and so placed as to revet these slopes as high as mean stage of water, and then willows should be planted in the berns. While on the accompanying tracings wing-dams to be constructed are shown, yet I would not recommend their construction until the sand-banks are protected. By referring to my report of last year, the location and extent of each of the "yellow banks" can be ascertained. They are given in the items of necessary improvements, numbered 3, 10, 18, 25, 27, 29. The total number of cubic yards of brush-work is 66,440, and, at an average expense of $1.25 per cubic yard, would cost to construct $83,050. The experiment might be tried on the "yellow banks" just above and below Rumsey's Bar. The cost of revetting these two would not be more than $30,000.

5. HEAD OF BEEF SLOUGH.

On the subsidence of the river after the last spring freshet it was found that a great change had taken place in the river between the Round Hill boom and the head of Beef Island. The old main channel to the left of Beef Island, which passes by the head of Beef Slough, had almost entirely filled up, while Horse Slough, to the right of the island, had very much deepened, and the amount of water flowing through it was nearly fourteen-fifteenths of the whole volume of the river above Beef Island. The cause of this change is evident. The Round Hill boom sent the current against the rocky left bank of the river, and caused an eddy just below itself, in which was deposited the large sand-bar, (No. 1 on tracing.) After striking the left bank, the current was deflected toward the head of Horse Slough, and the last high water completed the work, which no doubt has been progressing since the placing of the upper boom, of making Horse Slough the main channel.

There are some few snags in Horse Slough that should be removed, and a low-water wing-dam should be built from the point of rocks on

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the left bank of the river opposite the upper boom to past the head of Beef Island. This would cost as follows:

Wing-dams, 3,270 feet long, at $3.25	$10,627 50
Removing 50 snags, at $5	250 00
Total	10,877 50

The position of the winged end of the Round Hill boom, as shown on accompanying tracing No. 5, is that giving the widest opening between the boom and the left bank of the river, and it can be so swung as to entirely close the channel.

6. MOUTH OF THE RIVER. (SEE TRACING NO. 6.)

There seems to be but one way of improving this point on the river, and that is by contracting the channel-way until the current of the Mississippi River is reached, strong enough to carry away any silt brought down by the Chippewa River. This would require the building of 8,400 feet of wing-dams and jetties, which would cost $27,300. The above estimates are substituted for those given in previous report for the corresponding items of cost.

In the previous report, no estimates were made for improving the Dalles so as to permit of steamboat-navigation over them. I do not think that the commerce on the river will ever be of sufficient importance to warrant the construction of the locks and dams at the Upper and Lower Dalles. Before any well-digested plan for the improvement of the river below Eau Claire can be made, a continuous survey of the river must be made, and the experiment of protecting the steep slopes of the high "yellow banks" tried.

There are places on the river where even raft-navigation is difficult during low water. New channels are cut through the sand-bars each year, and new sand-bars are discovered on the subsidence of every freshet. I have no doubt the works recommended above at the head of Beef Slough and at the mouth of the river will improve the channel of the river at those points. During the season of 1875, the Beef Slough Company has run down the river from Chippewa Falls to the head of Beef Slough about 160,000,000 feet, board-measure, of loose logs. These logs were mostly run during a good stage of water, thus presenting a formidable obstacle to steamboat-navigation, at a time when but few natural obstructions existed. I would respectfully request that this report be appended to my report of January 30, 1875, (printed in Part 6, H. Ex. Doc. 75, second session, Forty-third Congress.) The field-work was done by a party under the charge of Max. E. Schmidt, who showed great intelligence, energy, and economy in doing the work intrusted to him.

Hoping that this may meet with your approval, I am,

Very respectfully, your obedient servant,

F. U. FARQUHAR,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

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APPENDIX P.

ANNUAL REPORT OF CAPTAIN WM. R. KING, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., September 19, 1876.

GENERAL: I have the honor to submit the following report on the works under my charge for the fiscal year ending June 30, 1876.

Very respectfully, your obedient servant,

W. R. KING,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

P 1.

TENNESSEE RIVER ABOVE CHATTANOOGA.

Work on this portion of the river being of a nature unsuited to the contract-system, authority had been procured to carry it on by hired labor.

The improvement consists in deepening the channel at the numerous shoals, by building stone dams to contract the water-way, by blasting rock from the channel, and by removing sand-bars, so as to secure at least 3 feet of water at all stages of river between Chattanooga and Knoxville.

The names and location of the shoals that have been considered as serious obstructions are shown on the small map of the Upper Tennessee, which forms a part of this report. Those marked 1 are essentially completed, those marked 0 are not begun, and those marked by fractions $\frac{1}{2}$, $\frac{3}{4}$, &c., are in a state of progress represented by the fraction.

The navigation of the river has already been greatly facilitated by these works, and the improvements are generally recognized and approved by river-men.

Low-water navigation between Chattanooga and Knoxville by steamers drawing 2 feet of water was formerly an impossibility, but that portion of the river between Chattanooga and Kingston, where the improvements are nearest completion, can now be navigated by steamers drawing nearly 3 feet of water during the whole year, and as the work is extended toward Knoxville there is every reason to expect that the same degree of success will attend it.

It is worthy of note that the Tennessee River is a remarkably satisfactory one to improve, since its regimen is almost fixed, the bed being cut through solid limestone for a great part of its course, and the banks being generally formed of rocky bluffs, or of earth thoroughly protected by willow and other aquatic trees, which grow almost to the lowest water-mark.

The improvements, therefore, instead of being uncertain in their results, as on many streams where a supposed improvement may prove only temporary in its action, or possibly prove a damage to navigation,

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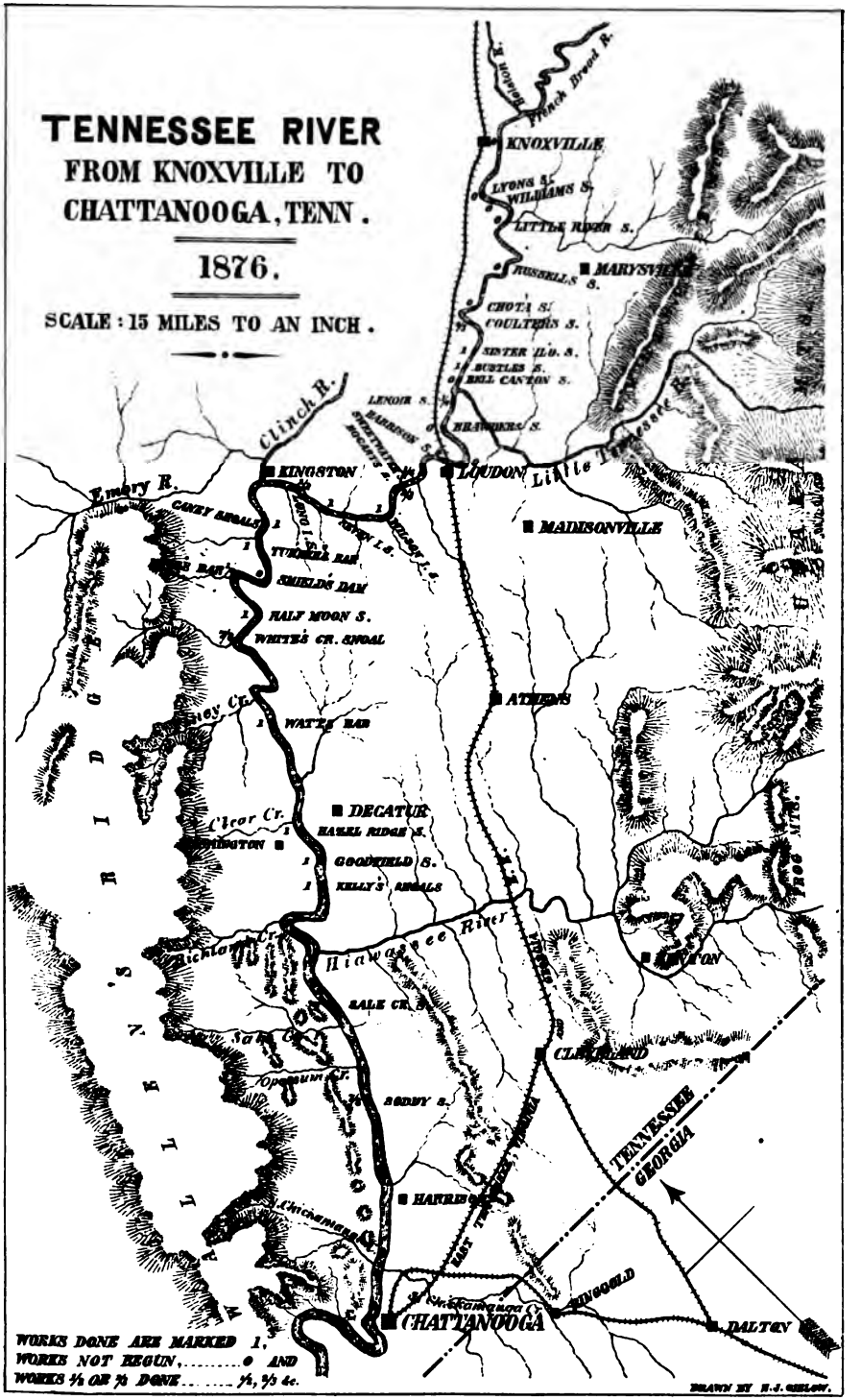

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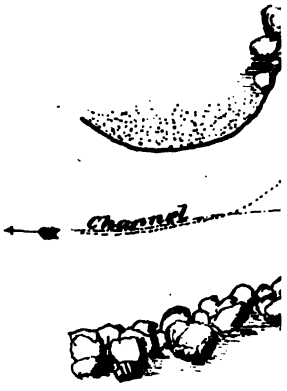

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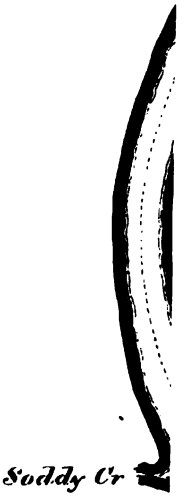

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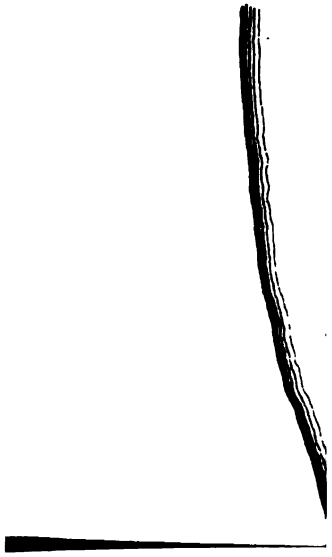

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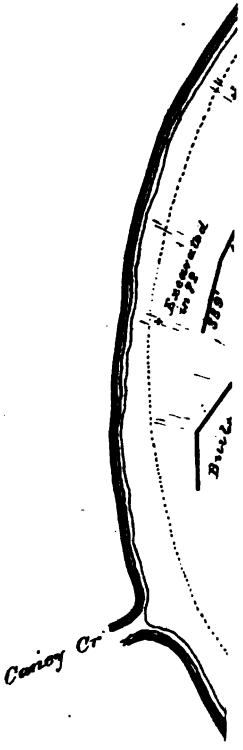

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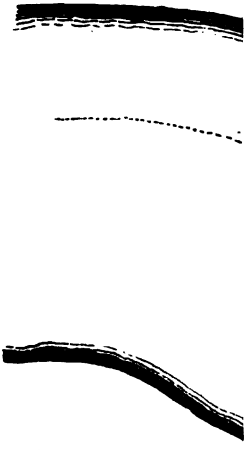

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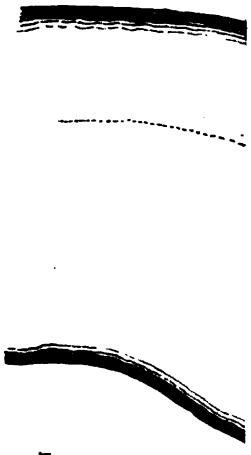

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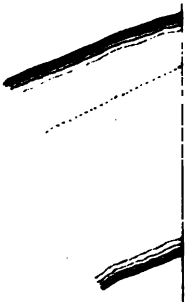

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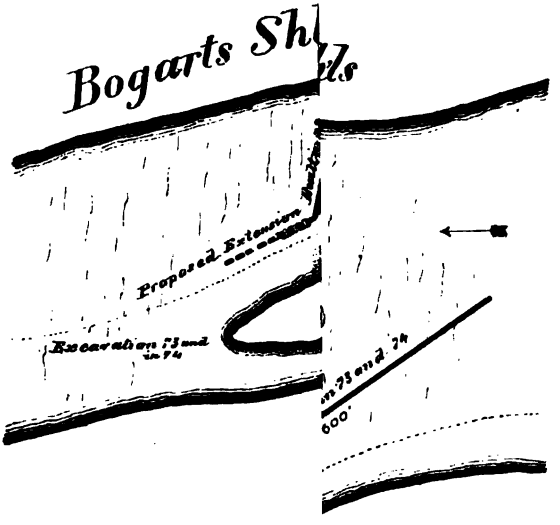

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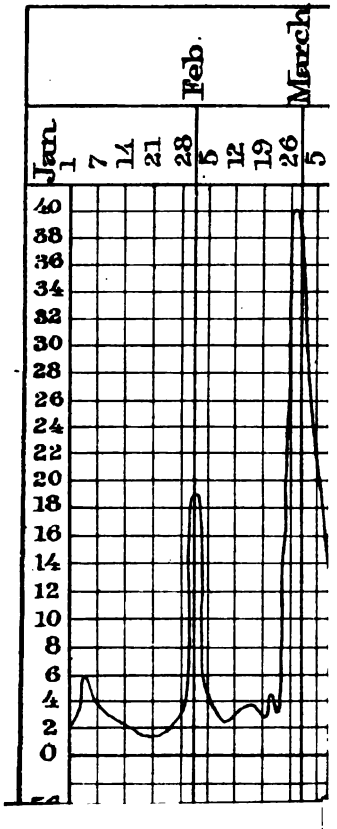

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by transferring the difficulty to another point, the works on the Tennessee may be regarded as efficient and permanent.

In some cases the works have failed to realize all that was expected of them, but it is thought that the fault was owing to a want of tightness in the dams, and that it can be corrected by using brush in connection with stone in building the dams.

The dams will also, in most cases, gradually become tighter, from the natural deposit of sediment in the spaces between the stones.

The entire absence of ice in this river is another reason why the dams may be considered permanent structures, and gives additional importance to these improvements, since the river can be navigated throughout the year, instead of being frozen up for a considerable portion of the time. The mode of carrying on this work is as follows:

1st. In building dams the location is so selected as to raise the water on the shoals, and, as far as possible, avoid the necessity of much channel-excavation. The stones are quarried at the most convenient points and conveyed in flat-boats to the site of the proposed dam, where they are thrown in, care being taken to give the dam the proper direction and to place the stones in as compact a mass as possible. Gravel and small stones are generally added to fill the interstices, and willow-brush are now being added to give still greater tightness to the dams. Willow-trees have been planted on some of the dams, but do not promise to grow unless finer materials can be massed about the roots, which it is proposed to accomplish by adding brush to the dams as above stated.

2d. Where rock is to be excavated from the channel, the drilling is generally done by hand, the man who holds the drill standing in the water and the strikers standing on a simple raft of timber.

The *débris* is generally removed by men going into water and shoveling the smaller fragments upon flat-boats, the larger pieces being lifted by derricks placed upon scows, the whole quantity removed being afterward deposited upon the river-bank, so that it can be seen at any time by the engineer in charge.

The whole number of cubic yards of rock so removed up to June 30, 1876, was 1,553.

The number of cubic yards of rock quarried and placed in dams was 34,053.

Gravel-excavation in the channel is carried on in the same way as the removal of blasted rock. The whole number of cubic yards removed up to June 30, 1876, was 1,050.

Since the removal of rock and gravel from the channel by the foregoing means requires extreme low water, and also that the water shall not be so cold as to prevent the men from working in it, the working season is limited to a very short interval between the spring and summer floods and the first cool weather in autumn, and as work has to be carried on at many places, often distant from each other, during this interval, it follows that considerable advantage would be derived if some economical device could be employed for removing rock and gravel at times when the water is too high or too cold to admit of working in the usual way. A scraper was made for this purpose during the past year, to be worked by a steamboat, and was partly tested in removing a gravel-bar, but a sudden rise in the river put a stop to its use for the season. The experiment was apparently successful, and it is proposed to renew it during the present low-water season.

Some inquiries have also been made in regard to the removal of rock by machinery, and, if any device is found worthy of trial, application will be made for authority to make the experiment.

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The number of men employed on these works has varied from 12 to 260.

Money statement.

Amount available July 1, 1875	$35,856 27
Amount expended during fiscal year ending June 30, 1876	27,994 26
Amount available July 1, 1876	7,862 01
Amount appropriated by act approved August 14, 1876	15,000 00
Amount (estimated) required for completion of existing project	75,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	35,000 00

P 2.

TENNESSEE RIVER BELOW CHATTANOOGA.

I. MUSCLE SHOALS.

This improvement consists in enlarging and repairing the old canal which was built about 40 years ago, and which had failed to accomplish the intended object of connecting the upper and lower Tennessee, because of difficult shoals both above and below the canal, viz, the Elk River Shoals above and the Little Muscle Shoals below, (see map of Muscle Shoals Canal herewith.) The present project of improvement includes the improvement of these shoals, as well as of the Big Muscle Shoals; the latter, however, being the only portion of the work under way at present.

This work is being carried on under five different contracts, as follows:

Name.	Date.	Contract.
T. Ford & Co	Dec. 13, 1875	Section 1, (repair and enlargement.)
Foster, Wiehl & Jackson	Dec. 13, 1875	Section 2. (do. do.)
Mathew G. Kennedy	Dec. 13, 1875	Sections 3, 4, 5, and 6.
Rice & Reid	Dec. 13, 1875	Section 7.
George Williams	Mar. 31, 1876	Locks numbers 3 and 4, (to rebuild.)

The first 4 of these contracts cover the completion of about 8 miles of canal, exclusive of locks, or a little more than one-half the length of the canal. They were to be completed by the 31st of May, but owing to delays from high water, rains, and hot weather, they have all been extended, and it is not probable that they will be completed before the 1st of December, 1876. With one or two exceptions, however, work has been going on with a fair monthly progress, as shown by the following table:

Work completed on Muscle Shoals Canal June 30, 1876.

Contractors.	Section.	Earth-excavation.	Earth-embankment.	Rock-excavation.	Slope wall.	Grubbing and clearing.	Removal of old locks.	Total value.
		Cu. yds.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Acres.*	*Cu. yds.*	
T. Ford & Co	1	69,941	64,849	4,418.4	.....	43.2	.....	$27,264 72
Foster, Wiehl & Jackson	2	31,500	12,000	2,650	575	3.7	.....	16,111 00
M. G. Kennedy	3	2,578	2,578	.....	.....	.....	.....	670 28
Do	4	2,030	1,224	.....	.....	34	.....	562 33
Do	5	44,281	10,135	450	.....	13	.....	8,399 39
Do	6	50,679	14,608	.....	.....	11	.....	9,390 89
Rice & Reid	7	50,000	6,000	20	.....	10	.....	10,339 98
	Lock.							
George Williams	3	1,775	.....	.....	.....	.....	425	1,312 50
Do	4	500	.....	.....	.....	.....	.....	250 00
Total amounts		253,284	111,484	7,598.4	575	84 13-20	425	74,301 00

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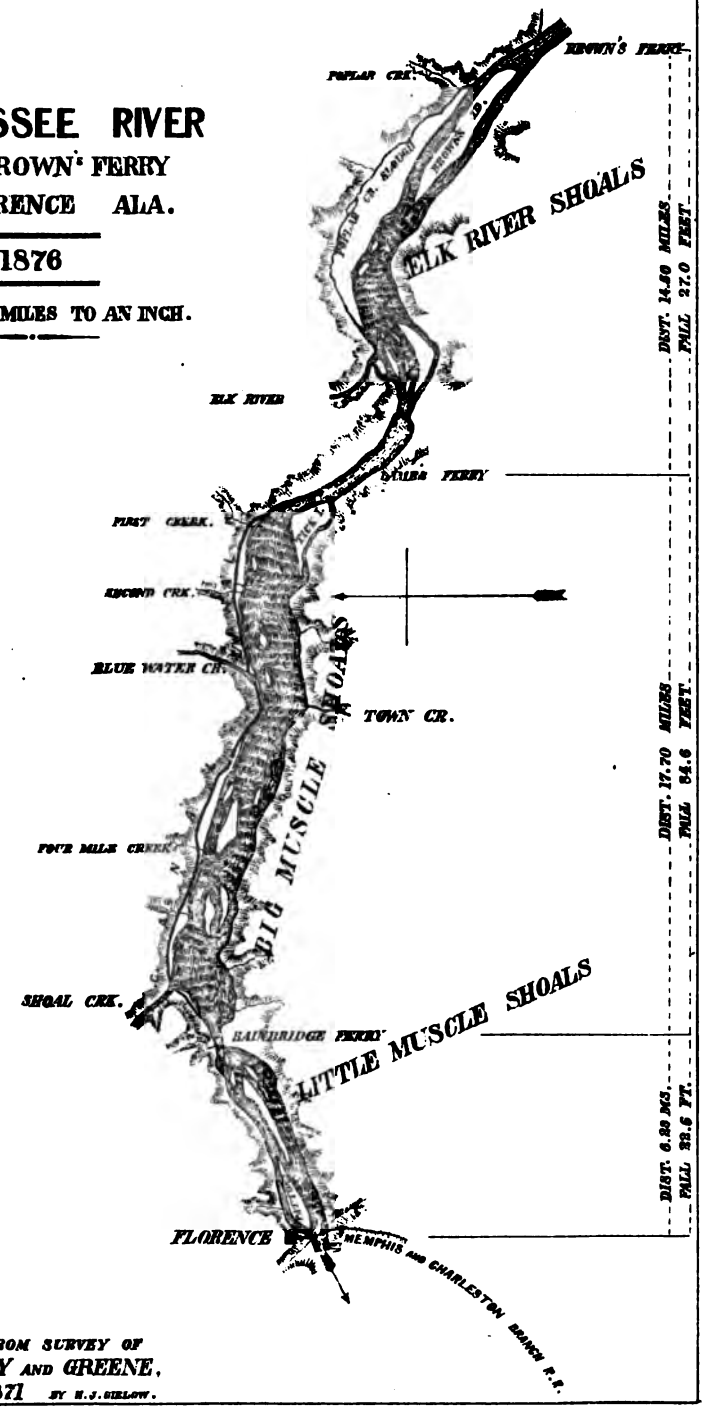
TENNESSEE RIVER

FROM BROWN'S FERRY TO FLORENCE ALA.

1876

SCALE : 5 MILES TO AN INCH.



REDUCED FROM SURVEY OF LTS. GREGORY AND GREENE, 1871 BY H.J. GILLOW.

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The section of Messrs. Rice & Reid has since been completed and accepted by the Government.

Owing to the amount of preparations required for building the locks, the contractor had accomplished but little work upon them at the end of the year, as shown by the table. He has since completed a railroad track along the tow-path, some ten miles in length, for hauling stone and other materials, and is now (September 19) engaged in quarrying and cutting stone for the locks, having nearly completed the excavation of the lock-pits.

The great importance of this work, forming as it does a connecting link between 300 miles of navigable waters in the Upper Tennessee with the Lower Tennessee, and in fact with the Mississippi and all its tributaries, for steamers drawing 3 feet of water, at all stages of the river, commends it to the judgment as one of the most important of our internal improvements, and will, I hope, secure, if not a liberal, at least a respectable appropriation.

The money already expended and the advantages to commerce can only be realized by completing it as fast as the work can economically be done.

There is every reason to believe that the work can be completed considerably within the estimated cost, if prosecuted as it should be, and under the same conditions it can be completed in about three years from the time adequate appropriations are available.

II. COLBERT SHOALS.

Work at this point is carried on by hired labor, and has been very much delayed on account of continued high water. The nature of the improvement is similar to that on the Upper Tennessee, and it is conducted in the same way.

During the past winter and spring but little work was done excepting looking after the engineer property in store, and preparing boats, tools, &c., for active operations.

At this time, September 19, work in the channel is making some progress, and the repairs and extension of the dams are also going on.

The number of men employed has varied from 5 or 6 to 120.

No separate appropriation is asked for this work, but in view of the fact that a recent appropriation bill contains an item for "Muscle Shoals" instead of the usual designation of "Tennessee River below Chattanooga," I would respectfully suggest that Congress be asked to adhere to the original designation, which will accomplish the same result and greatly simplify our accounts.

Money statement.

Amount available July 1, 1875	$499,263 73
Amount expended during fiscal year ending June 30, 1876	139,327 81
Amount available July 1, 1876, including $10,231.56 due on contracts	359,935 92
Amount appropriated by act approved August 14, 1876	255,000 00
Amount (estimated) required for completion of existing project	3,304,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	745,000 00

P 3.

CUMBERLAND RIVER.

This work has been carried on by hired labor, under the immediate charge of Captain L. C. Overman, United States Corps of Engineers, who reports as follows:

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The "working season" of the fiscal year ending June 30, 1876, was a very unfavorable one for the prosecution of work as proposed for the improvement of Cumberland River.

The whole fiscal year, however, was a favorable one for steamboating on said river, as the usual low-water season was short, and frequently interrupted by sudden and unusually high rises. The river, during July, 1875, reached a gauge of 27 feet 10 inches, and during September, 1875, reached a gauge-reading of 15 feet; a very unusual occurrence for the Cumberland River.

"*Channel-excavation*," by the method employed, was much interrupted, and almost impracticable during the whole season. But 13 days suitable for channel-work occurred, and these during the first half of the month of September.

Work was suspended in December, 1875, and not resumed till June 9, 1876, when the quarrying of stone for repair of dams at Davis Ripple was commenced, and repair of boats begun.

ESTIMATE OF WORK ACCOMPLISHED DURING THE FISCAL YEAR.

4,740 cubic yards of dam constructed in Harpeth Shoals.
175 cubic yards of rock excavated from channel in Harpeth Shoals.
525 cubic yards of dam constructed at Davis Ripple.
300 cubic yards of rock quarried for dam at Davis Ripple.

CONDITION OF WORK AUGUST 1, 1876.

During July, 1876, the dams in Harpeth Shoals (page 475 Report of Chief of Engineers 1871) were repaired and completed; to accomplish which about 1,500 cubic yards of stone were used, all taken from the quarry at Ashland Ferry Landing, and some 700 cubic yards of stone were quarried (at new quarry) for dam at Davis Ripple.

There remain only about 700 cubic yards of rock-excavation from river-bed, in channel, to complete the proposed improvement at Harpeth Shoals, which amount of excavation, owing to its being scattered over some 4½ miles of river, and to the frequent interruptions incident to such work, is estimated will cost at least $3,500 = $5 per cubic yard.

For Davis Ripple it is estimated that the dam-work will cost $2,500, in addition to the amount expended up to August 7, 1876, (when the balance of appropriation on hand was about $10,720, per L. C. Overman's estimate,) and that the gravel-excavation will cost about $2,000. The remaining $2,000 can be profitably employed in the removal of gravel bars, snags, &c., between Davis Ripple and Clarksville, Tenn.

* * * * * * *

Money statement.

Amount available July 1, 1875	$25,356 86
Amount expended during fiscal year ending June 30, 1876	12,365 25
Amount available July 1, 1876	12,991 61
Amount (estimated) required for completion of existing project	184,821 00
Amount that can be profitably expended in fiscal year ending June 30, 1878	75,000 00

P 4.

OOSTENAULA AND COOSAWATTEE RIVERS.

The work of improving these streams was continued during the year until the appropriation was nearly exhausted.

The improvements consisted in building wing-dams, blasting rock and bowlders, and in removing fish-traps, sand-bars, and snags from the channel; and was so nearly completed that in his annual report for the year ending June 30, 1875, the engineer in charge asked for no additional appropriation. Since that time a balance of $7,529.99 has been expended on the work.

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Money statement.

Amount available July 1, 1875	$7,552 05
Amount expended during fiscal year ending June 30, 1876	7,529 99
Amount available July 1, 1876	22 06
Amount (estimated) required for completion of existing project	13,208 50
Amount that can be profitably expended in fiscal year ending June 30, 1878	13,200 00

P 5.

EXAMINATION OF THE LITTLE TENNESSEE RIVER FROM THE CHILHOWEE MOUNTAINS TO THE GEORGIA LINE, IN MACON COUNTY, NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., February 7, 1876.

GENERAL: I have the honor to transmit herewith my report upon the examination of the "Tennessee River" (meaning the Little Tennessee River) "from the Chilhowee Mountains to the Georgia line, in Macon County, North Carolina," ordered by act of Congress approved March 3, 1875.

The act of Congress directing this examination, like the act of June 23, 1874, directing an examination of the lower part of the same river, designated it as the Tennessee River, but, as in the preceding case, the language of the act indicated that it was the Little Tennessee that was meant, and not the Tennessee River proper.

Under act of Congress approved June 23, 1874, this river was examined from its mouth up to the Chilhowee Mountains, a distance of 25 miles, the examination terminating at the mouth of Citico Creek. The present examination was begun where the last one terminated, and was carried to Rabun Gap, Rabun County, Georgia, near the source of the Little Tennessee. Rabun Gap lies 5 miles south of the boundary-line between North Carolina and Georgia, and is 109 miles, by water, from the mouth of Citico Creek, the point of beginning of the examination. The boundary-line between North Carolina and Tennessee crosses the river 24 miles above the mouth of Citico Creek.

In this distance of 109 miles the river falls 1,480 feet, an average of 13½ feet per mile. In its passage through the Smoky Mountains, from 15 to 30 miles above the mouth of Citico Creek, its width varies from 30 to 150 yards, and its fall from 10 to 40 feet per mile. It is simply a mountain-torrent, with the shallows, pools, rapids, and falls which characterize such streams, and it is incapable of improvement. There are fertile farming-lands near its headwaters, and in some parts of its valley; but the region through which it flows is a mountainous one of no great agricultural value, though rich in mineral resources awaiting development. This cannot take place until better means of transportation than those now existing are obtained, and as the river cannot be made useful for this purpose, it is probable that the solution of the question will be found in the construction of a railroad through Rabun Gap and the valley of the Little Tennessee, which offer no very serious obstructions to the accomplishment of such a work. Very bad mountain-roads are, at present, the only means of egress for the products of this region.

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More detailed information concerning this examination will be found in the report of Mr. Maurice Kingsley, assistant engineer, which is hereto appended.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. MAURICE KINGSLEY, ASSISTANT ENGINEER.

CHATTANOOGA, *August* 22, 1875.

MAJOR: I beg to submit to you my report on the examination of the Little Tennessee River from the Chilhowee Mountains to the Georgia State line.

I must preface this report by referring you to my report on the examination, in 1874, of this river from its mouth to the Chilhowee Mountains.

In it I stated that I saw no good reason for advising the improvement of the river above "Howard's old mill," 5 miles below the Chilhowee Mountains.

My examination this year of the river above the Chilhowee Mountains has in no wise changed this opinion; in fact, it has rather strengthened it. My reasons were that steamboats did, and could without danger, get up to the mouth of Citico Creek, at the foot of Chilhowee, in the floods of winter, which is the freighting season for their staple product, corn; and that producers from the farms within 5 miles of that head of navigation could either wagon down their produce to that point, or await a tide that the steamboats could come up upon, as that produce did not warrant the large outlay of improving and maintaining these 5 miles of river.

I took as my initial point the mouth of Citico Creek, the end of last year's survey; whence the general course of the Little Tennessee River is southeast to south-southeast through the Smoky range, across the State line of Tennessee and North Carolina, up to its source in the Blue Ridge, in Georgia, the "divide" of the waters of the Gulf and Atlantic.

From the mouth of Citico Creek to the Harding farm (14 miles) the river passes through the foothills of the Chilhowee and the Smoky range, broken ridges and bluffs running down to within one-half or one-quarter of a mile of the river, and leaving that breadth of fine farming-land on either side of it. A 200-acre farm of Judge Bright's, and the "Harding farm," of 300 acres, are as fine farms as any on the Tennessee River.

In these 14 miles there are three heavy shoals, of which the "Stretten Shoals" (3 miles above Citico) form a sufficient bar to navigation; but there is fair water between them, the average fall per mile being 13½ feet.

At the upper end of the Harding farm begins the Smoky range proper, and for the next 15 miles, to "Rocky Point," the river plunges through a deep cañon formed by the spurs of Bald Mountain on the north, and Unakoi Mountain on the south, over a succession of bars and falls; the stream varying from 30 to 150 yards broad, and the fall from 10 to 40 feet per mile. Of this, the worst part is the Narrows, just above the Harding farm, where for 3 miles the stream only averages 40 yards across, between perpendicular walls of rock, and the fall is over 30 feet per mile.

From Rocky Point to the Forks of "Little Tennessee" (23 miles) the spurs dwindle down gradually, the river becomes broader, and the fall drops to 15 feet per mile. Civilization also re-appears and increases as one goes up the river.

The Tuckasuge River, which joins the Little Tennessee at the Forks, brings about the same volume of water from the northern counties that the Little Tennessee brings from the southern, and from this point upland and river farms increase steadily in size and worth.

On Little Tennessee the country grows more open and prosperous for 36 miles, up to Franklin, a town of two hundred and fifty inhabitants, around which there is a broken plateau of fine farming country. The fall of the river for this 36 miles averages 13½ feet per mile.

This upland farming country continues up to the Georgia State line, 14 miles above Franklin, and thence 5 miles beyond, to Rabun Gap, in the Blue Ridge, the actual watershed.

The whole distance from Citico to Rabun Gap is 109 miles, over which the river has an average fall of 13½ feet per mile. The character of the river-bed from Citico to Franklin is virtually uniform; broad, flat layers of micaceous shales, granites, slates, &c., forming a succession of small falls of from 1 inch to 1 foot in height, while here

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and there a shoal of heavy broken bowlders, fallen from the cliffs above, makes a sudden shoot of water in a narrow place that no boat could steer in going down stream or warp herself up against in going up.

From Franklin to the State line the bottom of the river is composed of sand.

The rise of this year's flood, only exceeded by that of 1843, was, I was told, 16 feet; but I saw some places where it had risen from 22 to 25 feet.

In going up to Franklin the water was at its lowest stage, but on coming back the rains had swollen it to a 4-foot tide, when, if possible, the chances of navigation looked worse than in low water.

The following is a table of elevations and distances. The elevations are obtained by barometer, and, as compared with those of Professor Guyot, are too high. This I account for by the heavy and disturbed state of the atmosphere during the examination.

Place.	Distance.	Altitude.		Fall per mile.
		Kingsley.	Guyot.	
	Miles.	*Feet.*	*Feet.*	*Feet.*
Mouth of Citico Creek	0	801	.....	.....
Harding farm	14	936	880	9½
State line, (Tennessee and North Carolina)	24	1,224	1,168	28½
Rocky Point	29	1,306	.....	16⅖
Calhoun's	43	1,512	.....	15
Forks of Tennessee	52	.....	.....	.....
Alaskee Creek	59	1,745	.....	14
Nantahele Creek	62	.....	.....	.....
Franklin Ford	83½	2,055	1,920	13
Franklin, (one-half mile south of the river)	88	2,250	.....	.....
State line, (Georgia and North Carolina)	104	2,240	.....	9⅗
Rabun Gap	109	2,281	2,168	10
Average fall per mile	.....	.....	.....	13½

It is with regret that I report so adversely on the possibility of improving this river for navigation, as the country around it, from the Forks of Little Tennessee to Rabun Gap, is especially rich in mineral wealth, with no possible means of getting its products to market except by wagoning them for 75 miles over "impossible" roads, either to the Tennessee Valley or the State Railroad of Georgia.

As this is the only primitive formation southeast of the Rocky Mountains, and as its mineral wealth is very varied, it is of very great importance that it should be opened up. Its beds of "mica," both for size and quality, are equaled by none I have ever seen. Asbestos is found in large quantities. Agalmadalite, (soapstone,) for furnaces, tailors' chalk, &c. Corundum of various kinds, sapphires, garnets, rubies, beryl, and many other precious stones, including diamonds, as I saw one worth $400 that was panned out there by some one washing for gold. Silicon for glass-making. Chlorite and albite. Pymolite and ghentite. The ores of "nickel." Plumbago, graphite, and lead ores. Blue, green, and yellow copper-ores, and native copper. Fairly good silver-rock. Gold-rock and various gold-deposits. Magnetic and specular iron-ores of peculiar richness. Brown hematite iron-ore, manganese and chrome ores. Water-power unlimited, with untouched forests of oak, black walnut, ash, hickory, pine, maple, and poplar in closest proximity. And last, but not least, marbles, the true slate-marbles, of which there are nine shades, taking a polish that no limestone-marble can equal. I saw specimens, polished for the Smithsonian Institute to send to the Centennial, of the following colors: pure white, black, black with pure white streaks, black finely mottled with dark gray, flesh color, flesh color with mauve veins and green veins, and gray. I consider the marble, mica, and iron-ores most valuable to this section of the country; the iron-ores especially so, as among them there are steel-making ores.

The farm-products of the country adjacent to these minerals are considerable. Haywood and Macon Counties last year thrashed about 280,000 bushels of wheat, and raised from five to six times that amount of corn. Their apple-crop is immense. About 5,000 head of fat cattle are sent into Georgia annually. Their tobacco-crop is sufficient for the home consumption, and grapes are now being raised with good success.

From this short *résumé*, it will be seen that the husbandries would support a large mining population, could its mineral wealth be exported.

Various railroad projects from the southeast have been started, centering on Rabun Gap, and one is running to within 30 miles of it; but they are all too poor to go on at present, as also is one from Knoxville, Tenn., to Anderson, S. C.

Rabun Gap is the lowest practicable one through these mountains, with good grades up to it from the Tennessee side, and fair grades down into South Carolina.

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I give these items, as I have no hesitation in saying that this country must eventually be opened up by rail, and not by river. Meanwhile a mineral wealth, of untold value to the neighboring States, must lie idle.

I remain, yours respectfully,

MAURICE KINGSLEY.

Maj. WALTER MCFARLAND,
Corps of Engineers, U. S. A.

P 6.

EXAMINATION OF "FRENCH BROAD RIVER FROM THE HENDERSON COUNTY LINE TO ITS JUNCTION WITH THE HOLSTON, TENNESSEE."

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., February 7, 1876.

GENERAL: I have the honor to transmit herewith my report upon the examination of the "French Broad River from the Henderson County line to its junction with the Holston, Tennessee," which includes the examination of the "French Broad River from the Holston to Leadvale, Tennessee," both examinations being ordered by act of Congress approved March 3, 1875.

The part of the French Broad River described in this title includes the part lying between the Holston River and Leadvale, an examination of which is ordered by a separate clause of the same act. An examination of this same part of the French Broad River was made under act of Congress approved July 11, 1870, and the report upon it is to be found in the Report of the Chief of Engineers for 1871, beginning at page 491.

This examination is in continuation of the examination of the "French Broad River from Brevard, N. C., to the Buncombe County line," ordered by act of Congress approved June 23, 1874, the report of which is to be found in the Annual Report of the Chief of Engineers for 1875, part 1, beginning at page 817. The line designated in the one act as the "Buncombe County line," and in the other as the "Henderson County line," is the dividing-line of Buncombe and Henderson Counties, North Carolina, and crosses the French Broad at a point 39 miles below Brevard, and about 180 miles above its junction with the Holston River.

This whole distance of about 220 miles is naturally divided by its topographical features into three sections.

1st. The upper section, from Brevard to Asheville, a distance of 55 miles, with moderate fall:

	Distance.	Total fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
Brevard to county-line	38.84	46.58	1.20
County-line to Asheville	16.42	70.93	4.32
	55.26	117.51	2.12

2d. The middle section, from Asheville to Leadvale, a distance of 74 miles, in which the river breaks through the Unaka or Smoky Mountains; the fall varying from 2½ feet per mile to 26 feet per mile; the total fall being 929 feet.

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	Distance.	Total fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
Asheville (Senltes' Bridge) to Brush Creek	29.3	450	15.46
Brush Creek to Warm Springs	7.7	201	26.10
Warm Springs to Newport	31.0	263	8.50
Newport to Leadvale	6.0	15	2.50
Total	74	929	12.55

3d. The lower section, from Leadvale to the mouth of the French Broad, a distance of about 90 miles, with a probable average fall of 1 foot to a mile.

The upper and lower sections may be improved for navigation by the construction of wing-dams, the deepening of channels over bars and ledges, and the removal of drift, overhanging trees, &c.

The middle section can be fitted for navigation only by the construction of locks and dams.

ESTIMATE.

The estimated cost of improving that part of the upper section which extends from the Buncombe and Henderson County line to Asheville, as given by Assistant Engineer McCalla, whose report is transmitted herewith, is, omitting contingencies..	$59 790 00
The scattered character of the work would, however, raise the cost of rock-excavation to not less than $4 per cubic yard, which would increase the estimate	7,000 00
	66,790 00
Adding 25 per cent. for superintendence and contingencies	16,697 50
	83,487 50
Estimated cost for improving the part between Brevard and the Buncombe and Henderson County line, as given in the last Annual Report of the Chief of Engineers	41,600 00
Total for upper section	125,000 00

for making a channel 30 inches deep at low-water.

No estimate has been made for the improvement of the middle section, as it cannot be rendered navigable without the use of locks and dams; the total fall being 929 feet in a distance of 74 miles, for the passage of which more than 150 locks of 6 feet lift would be required. To make a proper estimate of the cost of such an improvement, a detailed survey of this section would have to be made, at a heavy expenditure, for which there seems to be no justification in the present or the probable near future wants of this region.

The estimated cost of the improvement of the lower section, so as to permit the passage during the season of low-water of vessels drawing 2½ feet, as given in the Report of the Chief of Engineers for 1871, before referred to, is $150,000.

By the census of 1870, the total population of the counties through which the French Broad River flows, namely, Transylvania, Henderson, Buncombe, and Madison, in North Carolina, and Cocke, Jefferson, and Sevier, in Tennessee, was found to be not quite 78,000. Knox County, Tennessee, in which the city of Knoxville lies, is not included in this enumeration, as it is entered by the French Broad only 6 or 8 miles in an air-line from its mouth.

Of these counties, Transylvania, Henderson, Madison, and about one-half of Buncombe, with a population of 27,000, might be benefited by the improvement of the upper section. As the middle section, however, is impassable, and as no railroad has yet reached Asheville at the

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foot of the upper section, such an improvement would be of little value, and there appears to be no good reason why it should be undertaken.

The population of the counties lying along the middle section, namely, one-half of Buncombe and Madison, in North Carolina, and Cocke and one-half of Jefferson, in Tennessee, runs up to nearly 30,000.

The improvement of the lower section would benefit about one-half of Jefferson and Sevier Counties, population over twenty thousand, and the small part of Knox County which lies between Sevier and the mouth of the French Broad.

The entire river runs through a mountain region, with fertile though narrow valleys along its upper and lower sections. This mountain region abounds in undeveloped mineral wealth, which in the future may require the improvement of this river and of some of its large branches. At present, neither the amount nor the value of the products of the region under discussion would seem to justify any attempt at the improvement of its low-water navigation.

Further information in relation to this subject will be found in the report of Mr. R. C. McCalla, which is sent herewith, and in the Reports of the Chief of Engineers, for 1871, page 491, and for 1875, part 1, page 817.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF R. C. M'CALLA, ASSISTANT ENGINEER.

CHATTANOOGA, TENN., *September* 1, 1875.

SIR: I have the honor to submit the following report on the examination of the French Broad River, from the Henderson County line in North Carolina to Leadvale, Tenn., made in accordance with your instructions of July 16, 1875.

The French Broad (Tah-kee-ostee of the Cherokees, which means *Racing-water*) is one of the largest tributaries of the Tennessee, draining the western slope of the Blue Ridge from the Yellow Mountain, in Watauga County on the northeast, to the Balsam Mountains in the west, embracing that territory in North Carolina comprising the counties of Buncombe, Yancey, Madison, Henderson, Transylvania, and Haywood; and in Tennessee of Cocke, Greene, Jefferson, and Sevier Counties. Its principal source is in the Blue Ridge, in Transylvania County, opposite to the main source of the Saluda River in South Carolina. Its great tributaries are the Big Pigeon and Nolichucky, the former entering the French Broad 4 miles, and the latter 1 mile above Leadville, a station on the Cincinnati, Cumberland Gap and Charleston Railroad, at the crossing of the French Broad, 12 miles south of Morristown, the county-site of Hamblen, situated on the East Tennessee and Virginia Railroad, 42 miles east of Knoxville.

From the Henderson County line to Asheville, the examination was made by chaining, leveling, and sounding the river and noting carefully all obstructions; while from Asheville to Leadvale the observations were conducted from within a canoe, and the distances and levels obtained by reference to the reports of railroad surveys, except from Newport to Leadvale, which are estimated.

The accompanying table gives all the information obtained in detail and the estimate for an improvement from the Henderson County line to Asheville, securing 30 inches extreme low water for the movement of small steamers.

The plan proposed is a system of rubble wing-dams, introduced to contract the waterway where necessary, so as to obtain the requisite depth of water.

Occasionally a bar or ledge can be removed cheapest by excavating a passage, whether it be composed of rock or gravel. In the construction of dams, the boat-channel is to be cleared of all loose rock and bowlders, which should be utilized in the construction of the dams.

The dams to be located and constructed so as to obtain the greatest effect at the least cost. At several points the plan of the dam is that of a wing at head of shoal, thrown diagonally down stream for about two-thirds the distance across, and thence

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a tail-dam to the foot of shoal, and parallel (or approximately so) to the natural margin of the river, on the boat-channel side. At other points wing-dams only, placed at proper intervals apart, will best accomplish the objects sought; and again in places the removal of loose rock alone will provide a sufficient depth of water.

By reference to the table it will be seen that the principal obstructions are Long Shoals, the shoal near Rice's, shoal below Rice's, Hunter's Island Shoal, Shut-in Shoal, beginning at Foster Johnson's, and the shoal at Patton's old bridge-site. Long Shoals and Patton's Bridge are the most objectionable, and at these points in the upward passage warping, doubtless, will have to be resorted to. The first incline of Long Shoals falls 3.93 feet in 633½ yards. The second incline falls 6.67 feet in 958½ yards. Paxton's Bridge Shoal falls 6.63 feet in 880 yards. The fall from the Head Ripple of Long Shoals to Mrs. Norcock's is 43.4 feet in 7.43 miles, or an average nearly of 6 feet per mile.

The distance from the Henderson County line to Smith's Bridge, opposite Asheville, is 16.42 miles, with a fall of 71 feet, or 4½ feet per mile nearly, the cost for improving which, upon the plan suggested, is shown in the following estimate:

4,250 cubic yards gravel and loose-rock excavation, at $1.50 per cubic yard...	$6,375
3,350 cubic yards loose-rock excavation, at $2.50 per cubic yard.....	8,375
1,500 cubic yards solid and bowlder rock excavation, at $3.50 per cubic yard..	5,250
14,316 cubic yards rubble wing-dams, at $2.50 per cubic yard.....	35,790
Removing drift from channels.....	1,250
Removing timber from banks.....	1,250
Cost from Tennent's Bridge to Swannanoa River.....	1,500
	59,790
Engineering and contingencies.....	12,000
Total cost from Henderson County line to Asheville.....	71,790
Add estimate from Brevard to Buncombe County line.....	29,687
Total cost from Brevard to Asheville = 55.26 miles.....	101,477

The details of the estimate for improving the French Broad, from Brevard to the Buncombe County line, will be found in the report on the same, of date February 15, 1875, together with a full description of the country and its resources, present and prospective, to which you are respectfully referred for all the information therein contained touching the proposed improvement of the Upper French Broad.

The French Broad River is naturally divided into three divisions, each with characteristics peculiar to itself. I would suggest Upper, Middle, and Lower as suitable names for the different divisions.

The upper division extends from its main source in the Blue Ridge, in Transylvania County, to Asheville, in Buncombe County. Its general course is very direct, bearing a little east of due north, and slowly diverging from a line parallel to the crest of the Blue Ridge. The country drained by this division falls gently, indeed almost imperceptibly, from this great mountain range. The small streams, even to the very base of the mountain, are low and marshy, reminding the observer of the low lands on the coast. Hence the little fall on most of this division, and the ease with which it may be improved for the passage of small steamers carrying from fifty to one hundred tons burden.

Fifty-five miles of this division, from Brevard to Asheville, are available for navigation, at a cost not exceeding the estimate, and the system proposed will better subserve the development of the agricultural and other interests of the country contiguous than a railroad, and for about one-seventh the cost.

However, the necessity for such an improvement must follow the completion of one or more railway lines to Asheville. This, doubtless, will be an accomplished fact at an early day, as one or more companies are now energetically engaged, even in these times of general depression, in pushing forward their lines.

It is proper and necessary to state also that this work, if embarked in, will subserve local interests almost exclusively, as the navigation of the Upper must be disconnected with that of the Lower French Broad for many years to come, except such connection as shall be afforded by the proposed (and partially built) railroad from Morristown to Asheville.

The middle division, extending from Asheville to Leadvale, in Jefferson County, East Tennessee, 74 miles in length, flows in a direction northwest, cutting through the entire range of the Iron or Great Smoky Mountains. In the passage of so large a river through a range of country with such topographical features, the engineer would naturally expect to find a succession of shoals, rapids, and cascades, if not an occasional cataract. In this he would not be disappointed here, for such are the chief characteristics of the middle division of the French Broad, without the cataract feature, however.

The passage down this division was made in a canoe, manned by two men, except

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from near the mouth of Brush Creek to near the Warm Springs, over which the canoe had to be transported by wagon.

From Asheville to Newport, a distance of 68 miles, the river is closely mountain-bound, abounding in vertical cliffs, bold projections, steep mountain-slopes, picturesque islands, and a number of small lateral streams, lined with laurel, white pine, hemlock, &c., full of shoals, and rapids, and cascades, which serve to conduct the drainage from the adjacent mountain lands into the main channel. At intervals, more or less remote, the precipitous slopes stand back, and a narrow belt of bottom intervenes to minister to the necessities of the small farmer, and with the wild game which abounds, such as the deer and the bear, and numerous smaller animals, enables him to work out, seemingly, a comfortable living. Such is a fair picture of this part of the French Broad as viewed by the impartial observer. At General Vance's, Alfred Alexander's, and Warm Springs, good farms are found, producing the various farm and garden products bountifully.

From Paint Rock to Leadvale, a distance of 31 miles, the fall of the river is less abrupt, the valley gradually opens, and good bottom-lands are found in considerable bodies, in a fair state of development. The rolling or mountainous lands on either side of the French Broad from Asheville to Paint Rock, back from the river, are represented as fair farming-lands, producing corn, wheat, rye, and tobacco of good quality. For fruit (particularly the apple and grape) and grass culture they are peculiarly well adapted, and on many of the small tributaries of the river fine farming-valleys are said to be in a good state of cultivation.

The French Broad and its great and small tributaries, cutting through and rising in the Iron or Great Smoky Mountain range, naturally come in contact with thousands of acres of as fine iron-ores and other minerals as can be found, perhaps, in any similar extent of country in the United States.

These are penetrated by the Nolichucky and Big Pigeon Rivers but a short distance above their mouths, and by the French Broad from Newport upward for some distance in the direction of Asheville. When the necessity arises, it will not be difficult or expensive to prepare these rivers for a safe downward flat-boat or barge transportation from the iron deposits to Leadvale, and thence onward to Knoxville, there to be utilized in the development of the varied and constantly-increasing mechanical and industrial arts.

The table accompanying this report gives the distances, and fall and rate of fall in feet per mile, of the French Broad from Asheville to Leadvale.

It will be observed that the distance is 74 miles, with a fall of 929 feet, or an average fall of 12.55 feet per mile. The greatest fall per mile is on the 7.7 miles from Brush Creek to Warm Springs, where the average is 26.10 feet per mile. The least fall is from Newport to Leadvale, the average of which for 6 miles is only 2.5 feet per mile.

It is proper to state that a slackwater improvement is the only feasible one for this portion of the river, the dams of which would average about 600 feet in length, entered by a system of locks, which would have to overcome an elevation of 929 feet vertical. Such an improvement, on a river with resources so limited and undeveloped, with a railroad located upon its immediate bank and partially constructed, and which doubtless will be completed at an early day, is not, in my judgment, to be seriously contemplated; hence I have deemed it wholly unnecessary to prepare an estimate of its probable cost. Neither do I consider it necessary, at present, to make any further examinations or surveys of this division of the river.

Your order before referred to required me to "examine the French Broad River from the Henderson County line to its junction with the Holston," which is about 6 miles east of Knoxville. The fund available having been exhausted before I reached Leadvale, induced me to close without an "examination" of the Lower French Broad division.

In conclusion, it affords me pleasure to testify to the valuable services rendered during the progress of this work by Messrs. J. L. Neal, James M. McIntire, and S. L. McCalla. The latter two handled the canoe skillfully and fearlessly through the long and dangerous descent of the rapids, thereby contributing largely to the success of the expedition.

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Examination of the French Broad River, from the Henderson County line, in North Carolina, to Leadvale, Tennessee.

Names of shoals and places.	Distance in miles from Henderson County line.	Elevation in feet above tide-water.	Length of shoals and intermediate spaces in yards.	Fall of each shoal and space in feet.	Remarks.
Head of Buck Shoal	0.66	2,059.79	.....	.....	
Foot of Buck Shoal	0.45	2,057.45	366⅔	2.34	
Henderson County line	0.00	2,056.30	800	1.15	
Avery's Creek	0.57	.....	1,000	.....	
Ripple at Horse Ford	0.66	2,055.21	166⅔	1.09	150 feet long; gravel-excavation = 375 cubic yards.
Head Ripple of Long Shoal	1.60	2,055.16	1,650	0.05	
Head, first plane of Long Shoal	1.74	2,054.19	250	0.97	750 feet long; gravel and loose rock = 1,250 cubic yards.
Foot, plane of Long Shoal	2.10	2,050.26	633⅓	3.93	1,900 feet long; loose rock wing-dam = 2,000 cubic yards.
Head, second plane and at mouth of Shoal Creek, Long Shoal.	2.73	2,048.53	1,106⅔	1.73	3,325 feet long; loose rock in channel = 500 cubic yards.
Foot, second plane of Long Shoal.	3.28	2,041.86	958⅓	6.67	2,875 feet long; loose rock wing-dam = 2,825 cubic yards.
Head of shoal, 500 yards below foot of Long Shoal.	3.56	2,040.99	500	0.87	1,500 feet long; loose rock in channel = 200 cubic yards.
Rice's Spring Branch	4.00	2,037.47	766⅔	3.52	2,300 feet long; loose rock in channel = 1,150 cubic yards.
Head of shoal, below Rice's	4.21	2,036.55	366⅔	0.92	1,100 feet long; channel of sufficient depth.
Foot of shoal, below Rice's	4.38	2,033.31	300	3.24	900 feet long; loose rock wing-dam = 1,066 cubic yards.
Head of shoal, at Hunter's Island.	4.92	2,033.31	600	0.00	1,800 feet long; channel of sufficient depth.
Foot of shoal, at Hunter's Island.	4.92	2,030.58	600	2.73	1,800 feet long; solid ledges and bowlder rock = 1,000 cubic yds.
Head of shoal, at Eli Glenn's	5.51	2,029.96	566⅔	0.62	1,700 feet long; channel of sufficient depth.
Foot of shoal, at Eli Glenn's	5.51	2,027.84	300	2.12	900 feet long; solid ledges and bowlders = 500 cubic yards.
Shut in	6.04	2,023.55	866⅔	4.29	2,600 feet long; loose rock wing-dam = 2,800 cubic yards.
Bent Creek	6.21	.....	300	.....	
Beginning of shoaly water, at Foster Johnson's.	6.33	2,022.80	200	0.75	1,500 feet long; channel of sufficient depth.
Shoaly water ends	7.46	2,015.12	1,988⅔	7.68	5,966 feet long; loose rock wing-dam = 3,000 cubic yards.
Head, Taylor's Ford Shoal	7.71	2,014.42	440	0.70	1,320 feet long; channel of sufficient depth.
Foot, Taylor's Ford Shoal	7.92	2,011.82	366⅔	2.60	1,100 feet long; loose rock formation = 1,000 cubic yards.
Mrs. Norcock's	8.09	.....	300	.....	900 feet long; channel of sufficient depth.
Julius Alexander's, bridge-site.	9.09	2,009.51	1,760	2.31	5,280 feet long; channel of sufficient depth.
Head of shoal, Patton's Bridge.	10.67	2,005.39	2,781	4.12	8,343 feet long; channel of sufficient depth.
Foot of shoal, Patton's Bridge.	11.17	1,998.76	880	6.63	2,640 feet long; loose rock wing-dam = 2,625 cubic yards.
Tennent's Bridge	12.38	1,996.57	2,129	2.19	6,387 feet long; loose rock to remove = 500 cubic yards.
Head of shoal, Tennent's Fish-trap.	13.14	1,994.94	1,337	1.63	
Foot of shoal, Tennent's Fish-trap.	13.14	1,993.97	1,337	0.97	From Tennent's Bridge to Swannanoa River; $1,500 will remove all obstructions.
Head of shoal, Patton's Fish-trap.	13.98	1,992.54	1,478	1.43	
Foot of shoal, Patton's Fish-trap.	13.98	1,991.79	1,478	0.75	
Swannanoa River	14.76	1,991.00	1,373	0.79	
Smith's Bridge, opposite Asheville.	16.42	1,985.37	2,921	5.63	8,763 feet long; rock and gravel bars = 3,000 cubic yards.
Total	16.42	.....	.....	70.93	

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RECAPITULATION.

	Miles.	Fall, in feet.	Rate of fall per mile, in feet.
From Henderson County line to head ripple of Long Shoal	1.60	1.14	0.71
Head ripple of Long Shoal to foot of Taylor's Ford Shoal	6.32	43.34	6.86
Foot of Taylor's Ford Shoal to foot of Patton's Bridge Shoal	3.25	13.06	4.00
Foot of Patton's Bridge Shoal to mouth of Swannanoa River	3.59	7.76	2.16
Mouth of Swannanoa River to Smith's Bridge, at Asheville	1.66	5.63	3.39
Henderson County line to Smith's Bridge, at Asheville	16.42	70.93	4.32

Estimate for improving the French Broad River from the Henderson County line to Asheville, securing a channel in width of not less than 45 feet, and a depth of 30 inches, extreme low water.

4,250 cubic yards gravel and loose rock excavation, at $1.50 per cubic yard	$6,375 00
3,350 cubic yards loose rock excavation, at $2.50 per cubic yard	8,375 00
1,500 cubic yards solid and bowlder rock excavation, at $3.50 per cubic yard	5,250 00
14,316 cubic yards rubble wing dams, at $2.50 per cubic yard	35,790 00
Removing drift from channel	1,250 00
Removing timber from banks	1,250 00
Cost from Tennent's Bridge to Swannanoa River	1,500 00
	59,790 00
Engineering and contingencies	12,000 00
Total cost from Henderson County line to Asheville	71,790 00
Add estimated cost from Brevard to Buncombe County line	29,687 00
Total cost from Brevard to Asheville, 55.26 miles	101,477 00

Levels and distances on the French Broad River, from Smith's Bridge at Asheville, N. C., to Leadvale, Tenn.

From—	To—	Distance, in miles.	Elevation above tide, in feet.	Fall, in feet.	Average fall per mile, in feet.
Smith's Bridge			1,985.0		
	General Vance's	5.0	1,941	44	8.8
General Vance's	Alexander's	5.7	1,799	142	24.91
Alexander's	Brown's	4.1	1,735	64	15.61
Brown's	Marshall (a)	6.6	1,648	87	13.18
Marshall	Brush Creek	7.9	1,535	113	14.30
Brush Creek	Warm Springs	7.7	1,334	201	26.10
Warm Springs	Paint Rock (b)	6.0	1,275	59	9.83
Paint Rock	Newport (c)	25.0	1,071	204	8.16
Newport	Leadvale (d)	6.0	1,056	15	2.5
Smith's Bridge	Do	74.0		929	12.55

(a) County-site of Madison County. (b) State-line. (c) County-site of Cooke County. (d) Crossing of Cincinnati, Cumberland Gap and Charleston Railroad, twelve miles south of Morristown.

NOTE.—Tide-levels from Swannanoa River to Paint Rock were obtained from recent surveys of the Western North Carolina Railroad; from Paint Rock to Newport, from the railway reports of 1836–'37, made under the direction of General William Gibbs McNeil, of the United States Engineer Corps; and from Newport to Leadvale the fall is measured by the eye, and, therefore, is only approximate.

Very respectfully, your obedient servant,

R. C. McCALLA,
Civil Engineer.

Maj. WALTER McFARLAND,
Corps of Engineers, U. S. A.

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EXAMINATION OF THE OCMULGEE RIVER, GEORGIA, FROM THE CITY OF MACON TO THE CITY OF COVINGTON.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., February 19, 1876.

GENERAL: I have the honor to transmit herewith my report on the examination of the "Ocmulgee River, Georgia, from the city of Macon to the city of Covington," made under the provisions of an act of Congress approved March 3, 1875.

The Ocmulgee River does not extend as high as Covington, the upper terminus mentioned in the act, but is formed by the junction of the Yellow and South Rivers, which unite about 20 miles below that point. A little over 40 miles below this junction the city of Macon is reached. The examination of this distance of about 60 miles was begun at the Georgia Railroad bridge, which crosses the Yellow River about 3 miles from Covington, a city of eleven hundred inhabitants. The surveying party dropped down the stream in flat-boats built for their use, and examined the various obstructions as they were reached.

The funds available permitted an examination only, and not a survey. An accurate knowledge of the length of this line and of the fall in the river was, however, obtained by a survey made in 1871, under act of Congress approved March 3, and Senate resolution of March 30, of that year, the report of which will be found in the Report of the Chief of Engineers for 1872, pages 509 and 530, "Line of water communication between the Mississippi River and the Atlantic." In this distance of 61 miles the river varies from 50 yards to 120 yards in width, is very crooked and full of obstructions, and has a fall of about 360 feet, or 6 feet per mile. Between Covington and Macon there are not less than sixty of these obstructions, or about one to every mile, with from 12 to 24 inches of water over them when the river is at a low stage. The worst of these are Loyd's Shoal, 36 miles above Macon, where the river falls 40 feet in 2 miles, and Cedar Shoals, 5 miles below Covington, where it falls 63 feet in less than a mile. This part of the river passes through or touches Newton, Jasper, Butts, Monroe, Jones, and Bibb Counties, whose united population is about eighty thousand. It cannot be fitted for navigation except by constructing locks and dams and establishing the slack-water system at a very large cost, and there is no good reason for doing this, as the benefit to be derived from it would be confined entirely to these few counties, the value of whose products bears no reasonable proportion to the probable cost of such an improvement.

The following description of the obstructions in this part of the river, with the estimated cost of overcoming them, was submitted by the assistant engineer, B. W. Frobel, who conducted the examination:

The survey was begun at the Georgia Railroad bridge over the Yellow River, on the 27th of July. The time selected for the work was exceedingly favorable, the water in both rivers being lower (as I am informed by persons living near them) than it had been for many years past.

The first obstruction met with is at the railroad-crossing, and is known as *Bridge Shoal.* It consists of rock-reefs, crossing the river at right angles with the bed, and has a fall of 4.372 feet. From this point to Cedar Shoal (5 miles) the current is slack, the banks are high, and the bottom mostly of rock; the width of the channel is very uniform, and about 125 feet.

Merriwether's Shoal is about one-fourth of a mile below Bridge Shoal. It is a flat reef of rocks, with 2 feet of water on it. Soundings between the shoals, from 1 to 3 feet.

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One and one-quarter miles below this is *Hendrick's Shoal*, at the mouth of Hendrick's Creek. It consists of some large detached rocks in mid-channel, which are bare at low water.

The next obstruction is at the mouth of Turkey Creek, and is known as *Crew's Shoal*. It is a rock-bar, with 2 feet of water on it. From Crew's Shoal to Cedar Shoal soundings from 3 to 4 feet. This portion of the river needs ponding to give the required depth. This can be done without difficulty, as the bottom is of rock, and the banks firm and sufficiently high to prevent flooding any portion of the adjacent lands. For this purpose a dam at Merriwether's Shoal with lock of 6 feet lift, and a dam at Crew's Shoal, with lock of 4 feet lift, will be sufficient.

Estimated cost.

One lock, 6 feet lift	$12,000
Dam 90 feet long	1,260
One lock, 4 feet lift	8,000
Dam 90 feet long	1,260
Removing 60 cubic yards rock at Hendrick's Shoal	180
	22,700

Cedar Shoal presents the next obstacle, and here the river has a fall of 63 feet in less than 1 mile. To render this passable for vessels drawing 4 feet, the upper and lower dams, as designated in the accompanying map, should be raised each 1 foot. A canal 600 feet long should be constructed between stations 3 and 9 with a lock of 18½ feet lift, and a similar lock at stations 9, 10. The left-hand island chute should be deepened, and the channel enlarged at stations 16, 17, 18, in the diagram, and a lock of 7 feet lift placed on the right of the lower dam, opposite station 28.

Estimated cost.

One lock, 18½ feet lift	$37,000
One lock, 18½ feet lift	37,000
One lock, 7 feet lift	14,000
Rock-excavation, 2,100 cubic yards, at $1.50	3,150
600 feet of canal	8,400
Raising upper dam 1 foot	406
Raising lower dam 1 foot	980
	100,936

One-half mile below Cedar Shoal is *Hanson's Shoal*. It is a rock-bar 300 feet long, and has 1 foot of water on it. A dam with lock of 9½ feet lift, and a similar lock and dam between this and the foot of Cedar Shoals, will give sufficient water as high as the lower dam.

Estimated cost.

Two locks, 9½ feet lift	$37,000
Two dams, 100 feet long	2,600
	39 600

From Hanson's Shoal to Dried Indian Shoal, the river is greatly obstructed by reefs and bars, and needs ponding.

Dried Indian Shoal is 1,200 feet long, with a fall of 7.247 feet. It is very shallow and filled with bowlders and loose rock. A dam at the foot of the shoal, with lock of 10 feet lift, will give sufficient water to Hanson's Shoal.

Estimated cost.

100-foot dam	$1,400
One lock, 10 feet lift	20,000
	21,400

From Dried Indian to Flat Shoal, there are numerous reefs and bars, with soundings from 1 to 6 feet.

Flat Shoal is a rock-bar 600 feet long, with a fall of 18 inches. A dam at the foot of this shoal, with a lock of 4 feet lift, will pond over all obstacles as high as Dried Indian.

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Estimated cost.

Dam 100 feet long	$1,400
One lock, 4 feet lift	8,000
	9,400

From Flat Shoal to Webb's Shoal soundings, from 3 to 10 feet.

Webb's Shoal is a rock-reef 40 feet long, and with a fall of 1 foot. A dam is needed here with a lock of 4 feet lift.

Estimated cost.

Dam 100 feet long	$1,400
One lock, 4 feet lift	8,000
	9,400

Between Webb's Shoal and Lee's Shoal there is deep water.

Lee's Shoal is very shallow and should be ponded over. This can best be done by a dam at Allen's Shoal, 1 mile below. The channel here is filled with rock-reefs. Allen's Shoal being the last of them, a dam here, with lock of 7 feet lift, will be required.

Estimated cost.

Dam 100 feet long	$1,400
One lock, 7 feet lift	14,000
	15,400

From Allen's Shoal to Indian Fishery (1 mile) the water is deep and the channel clear.

Indian Fishery.—The river is 350 feet wide. The shoal forms a natural dam with deep water above and below it, and has a fall of 12 feet. A lock of 12 feet lift is needed here, and a channel cleaned out through the left-hand island chute below the shoal.

Estimated cost.

600 cubic yards solid-rock excavation, at $3	$1,800
One lock, 12 feet lift	24,000
	25,800

From Indian Fishery to Barnes's Shoal there is deep water and a clear channel.

Barnes's Shoal is at the junction of Yellow and South Rivers. Like Indian Fishery, it is a rock barrier crossing the river, and forming a fine, perfect dam. There is deep water above it. A lock of 11.5 feet lift is needed here, and the channel in the left-hand island chute below should be cleaned out.

Estimated cost.

One lock, 11.5 feet lift	$23,000
Removing 1,300 cubic yards rock, at $3	3,900
	26,900

Between Barnes's and Lemon's Shoals the following work will be necessary to give 4 feet of water at the lowest stage:

One reef near the foot of shoal, 300 cubic yards solid rock, at $3	$900
2,000 cubic yards loose rock, at $2	4,000
400 cubic yards jetty, built of same, at 50 cents	200
Reef near Smith's Ferry, 300 cubic yards solid rock, at $3	900
Polk's Island Reef, 100 cubic yards solid rock, at $3	300
70 cubic yards of riprap dam, built of same	.35
	6,335

At *Lemon's Shoal* the channel is about equally divided by a small island. The left-hand channel is greatly obstructed by rock partially exposed, while the right-hand channel is free of rock and has from 7 to 10 feet of water. At the foot of the island a reef of solid rock, exposed, crosses the river, completely closing the right-hand channel

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and throwing the entire stream on the left-hand bank through an opening about 50 feet wide. The current here is very rapid, and the sharp angles made by the reef and island present serious obstacles to a boat ascending it. To remove the difficulty, the left-hand channel at the head of the island should be closed, and a channel cut through the reef at the lower end of it, near the right bank. The present channel between the reef and the foot of the island should be closed, and a rubble-dam built across the right-hand channel at Station No. 7 in the diagram.

Estimated cost.

Solid-rock excavation, 1,200 cubic yards, at $1.50	$1,800
180 cubic yards dam, built of same, at 50 cents	90
	1,890

From Lemon's Shoal to Key's Ferry the water is deep.

At *The Ferry* there is a reef 200 feet long which must be cut down 6 inches.

Estimated cost.

300 cubic yards solid-rock excavation, at $3	$900

The Alcovy River comes in near Key's Ferry with a volume of water equal to Yellow River.

From Key's Ferry to *Harvey's Mill* there is deep water. At the mill there is a shoal 600 feet long, with a fall of 4 feet, measured from the surface of the water above the dam. By removing the dam the fall will be distributed over a much greater distance. The river here is very wide, and the obstacle may be removed by contracting the channel and clearing out the bowlders and loose rock near the right bank.

Estimated cost.

Removing 1,800 yards loose rock from channel, at $2	$3,600 00
Constructing jetties of the same, at 50 cents	900 00
	4,500 00

The next shoal is known as *Leverett's Shoal.* Here the river is divided by a small island, the best water being near the right bank. The passage to the left of the island should be closed, and a reef and some loose rocks removed from the other channel.

Estimated cost.

Removing 500 cubic yards loose rock, at $1	$500 00
Building dam of same, at 50 cents	250 00
Excavating 91 cubic yards solid rock, at $3	273 00
	1,023 00

From Leverett's Shoal to *Cap's Shoal* there is from 7 to 10 feet water. The river here is divided by islands into three channels, the shoal being immediately at the foot of the upper island. It consists of a reef of solid rocks and bowlders crossing the river and damming up the water, the greatest fall being within 100 feet of the upper reef. By cutting a channel-way through this reef, near the left bank, and confining the water to the passage-way between the two islands, immediately below the shoal, the difficulty may be removed and a lock avoided. The channel to the left of Mountain Island should be closed.

Estimated cost.

7,000 cubic yards solid-rock excavation, at $3	$21,000
300 cubic yards dam, built of same	150
	21,150

Should a lock, however, be deemed best, the proper position for it will be found in the passage to the left of Mountain Island. This chute is about 80 feet wide, and deep above and below the shoal.

Estimated cost.

Dam	$1,400
One lock, 5½ feet lift	11,000
	12,400

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Although the expense of an open channel is greater, it would be infinitely preferable to a lock. Between Cap's Shoal and Lloyd's Shoal there is good water.

Lloyd's Shoal is nearly 2 miles long, and has a fall of 40 feet. It is very shallow, and the channel is greatly obstructed. Ponding here is necessary, and it can be readily done, as the bottom is of solid rock and the bank sufficiently high. Four locks and dams will be needed.

Estimated cost.

Four dams, 1,600 feet	$22,400
Four locks, 10 feet lift	80,000
	102,400

Just below this shoal, and near the mouth of Herd's Creek, there is a narrow reef with 1 foot of water on it. Requires—

Solid-rock excavation, 90 cubic yards, at $3	$270

From this reef to Pittman's Shoal there is deep water.

Pittman's Shoal is a succession of reefs, with a fall .194 per 100 feet. An island divides the channel here, the best water being to the left of the island. The passage to the right of the island should be closed, and the reefs and loose rocks removed from the other channel.

Estimated cost.

1,500 cubic yards solid-rock excavation, at $3	$4,500
1,000 cubic yards loose-rock excavation, at $1	1,000
Building 150 cubic yards dam of same, at 50 cents	75
	5 575

Between Pittman's and Roach's Shoals, soundings from 6 to 14 feet.

Roach's Shoal, like Pittman's, is formed of reefs and bowlders, and has a fall of .194 foot per 100 feet. A good channel may be formed on the right bank by removing loose rock and bowlders and building a jetty from the head of the shoal to Roach's mill.

Estimated cost.

Removing 3,000 cubic yards bowlders and loose rock, at $2	$6,000
Building with these 3,000 cubic yards jetty, at 50 cents	1,500
	7,500

From Roach's Shoal to Lamar's Shoal there is deep water.

Lamar's Shoal.—The river here is divided by a small island, the best water being in the right-hand channel. By closing the other channel and removing a fish-trap dam, and some loose rock and bowlders from this, sufficient water may be had. A jetty should be built from the lower end of the island, inclining toward the right bank.

Estimated cost.

200 cubic yards solid-rock excavation, at $3	$600
300 cubic yards loose-rock excavation, at $1	300
Building dam of same	250
	1,150

From Lamar's Shoal to Seven Islands there is deep water and no obstructions. This shoal is a rock-bar 1,300 feet long, and, with a fall of 19.515 feet, 20 feet of lockage and a canal 600 feet long will be needed here. Below the shoal, the passage between the islands and the right bank should be cleaned out and the other passages closed. This will throw a volume of water into the open channel of sufficient depth.

Estimated cost.

600 feet of canal	$7,000
Locks 20 feet lift	40,000
1,000 cubic yards solid-rock excavation, at $3	3,000
1,000 cubic yards loose-rock excavation, at $1	1,000
2,000 cubic yards dams and jetties, built of same	1,000
	52,000

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From Seven Islands to Little Sandy Creek there are no obstructions, and the water is deep. Here are some detached rocks that should come out, (50 cubic yards.) One mile below this a small island divides the channel. There is a rock-bar at the head of this island with a fish-trap dam on it. This should be removed and the left-hand channel closed. For 500 feet below the island there is a sand-bank with from 2.5 feet to 3 feet water, the river being 300 feet wide. A jetty should be built from the foot of the island to the end of this bank, inclining to the right bank of the river.

Estimated cost.

Removing fish-trap dam, 66 cubic yards	$66
Building dam with same at head of island, 50 cents	33
Removing 200 cubic yards loose rock from channel, at $1	200
Building jetty of same, 50 cents	100
	399

From Island Shoal to *Ward's Ferry* there is deep water; 300 feet above the ferry a narrow reef crosses the channel, which is here 200 feet wide. The opening through this reef needs enlarging 50 feet. About 500 feet below the ferry there is a ledge of bare rock extending nearly across the river. There are 5 feet of water in the opening through this ledge; 30 feet of the ledge should be taken off. For 200 feet below this ledge there are only 3 feet in the channel. This may be deepened sufficiently by building a jetty from the ledge to the lower edge of shoal.

Estimated cost.

Upper reef: excavating 20 cubic yards solid rock, at $3	$60
Lower reef: excavating 30 cubic yards solid rock, at $3	90
200 feet jetty, 50 cubic yards, at 50 cents	25
30 cubic yards, at $2	60
	235

Between Ward's Ferry and *Big Sandy Creek* there are several small sand-bars with 2½ feet of water on them.

From Big Sandy Creek to *McArthur's Ferry* there is deep water and a clear channel. Near the ferry two narrow reefs with 2 feet water cross the river. One mile farther down there is another reef, with 3 feet on it.

Estimated cost of work on this part of the river.

2,000 cubic yards sand-excavation, at 60 cents	$1,200
Removing 2 reefs, 60 cubic yards each, at $3	360
Removing 1 reef, 30 cubic yards, at $3	90
	1,650

The next obstruction is at *Head's Shoal.* This is a flat reef with but little fall. It begins a quarter of a mile above the mouth of Towaliga River. The upper part consists of bowlders and loose rock. Below these there is a ledge 50 feet long with 2½ feet on it. The river here is 350 feet wide, the best water being near the right bank.

The channel above the reef should be cleaned out, and a wing-dam built on the lower edge of it.

Estimated cost.

Removing 500 cubic yards of loose rock, at $2	$1,000
Building wing-dams of same, at 50 cents	250
	1,250

Between Head's Shoal and *Glover's Shoal* there are five reefs, with 2 feet of water on them. These reefs are in deep water, and are very narrow. Immediately above Glover's Shoal three similar reefs cross the river, with 18 inches of water on them. They should be removed.

Estimated cost.

Removing 5 reefs, 30 cubic yards each, 150 cubic yards, at $3	$450
Removing 3 reefs, 30 cubic yards each, 90 cubic yards, at $3	270
	720

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The upper part of Glover's Shoal consists of three reefs, with deep water between them. One thousand eight hundred feet from the head of the shoal the fall becomes rapid, and the channel is filled with fixed rock and bowlders. A good channel may be made above the fall by cutting through the reefs. From the head of the principal fall a canal will be needed 1,800 feet long, and with a lock of 18 feet lift. The channel at the foot of the shoal should be cleaned out. The canal may be built near the left bank in the river-bed.

Estimated cost.

Canal	$9,000
Lock, 18 feet lift	36,000
Removing 3 reefs, 30 cubic yards each, at $3	270
Improving channel below shoal	1,000
	46,270

About 1,000 feet below *Mitchell's Ferry* there is a narrow rock and sand bar, with 2 feet water. The river here is 360 feet wide. Five hundred feet below the sand-bar there is a rock ledge 50 feet long, with 2½ feet water. The channel over these bars should be deepened, and one or two detached rocks removed.

Estimated cost.

Excavating 220 cubic yards solid rock, at $3	$660
Excavating 45 cubic yards sand and rock	45
	705

From this point to *Mitchell's Shoal*, 4 miles, the water is deep, and there are no obstructions. The upper reef here is very narrow, and has a fish-trap dam on it; deep water above and below it. The dam should be removed, and the channel deepened. At the lower reef an island divides the channel. This reef is narrow, (10 feet,) and has a fall of 1.8 feet. The best water is to the left of the island. The channel to the right should be closed, and the reef cut away near the left bank.

Estimated cost.

Removing fish-trap dam, 36 cubic yards, at $1	$36 00
Solid-rock excavation, 375 cubic yards, at $3	1,125 00
Building dam with same, at 50 cents	187 50
	1,348 50

One mile below Mitchell's Shoal there are two reefs in 5 feet water. They are 10 feet long, and have 18 inches water on them. Estimated cost of removing them:

Excavating 90 cubic yards solid rock, at $3	$270

Jarrel's Shoal is the next obstruction. It consists of a rock bar 200 feet long, with 2½ feet of water on it. The channel should be contracted by jetties. Six hundred feet below this there is a reef with 1 foot of water. Two hundred feet farther down there is a similar reef. Five hundred feet from this another reef crosses the channel, with 3 feet of water. One hundred feet below this there is a reef with 2 feet water. Upon this there is a fish-trap dam. Channels should be excavated through these reefs, and the dam removed.

Estimated cost.

Excavating 502 cubic yards solid rock, at $3	$1,506
Excavating 330 cubic yards loose rock, at $1	330
Building jetties with same, at 50 cents	165
	2,001

Clarke's Shoal begins at the head of Long Island and ends 100 feet below it. It consists of six narrow reefs, one at the head of Long Island, four reefs half-way down the island, and one at the foot of it. To give the proper depth will require—

80 cubic yards solid-rock excavation, at $3	$240
100 cubic yards loose-rock excavation, at $1	100
	340

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Falling Creek Shoal is at the mouth of Falling Creek. It consists of seven reefs of rock, with deep water between them. To open a channel through these will require—

518 cubic yards of solid-rock excavation, at $3 ..... $1,554

Immediately below the shoal, two small islands divide the channel. The best water is to the right of the upper island and to the left of the lower one. The opposite channels should be closed. In the lower island chute there are three reefs that should be removed.

Estimated cost.

Removing 222 cubic yards solid rock, at $3	$666
Building dams with same, at 50 cents	111
	777

Between Falling Creek and Dame's Shoal the water is very deep, except at the ferry, where there is a reef of detached rocks. This needs—

80 cubic yards rock-excavation, at $2.50 ..... $200

At *Dame's Shoal* the river is very wide, and is filled with small islands. The shoal is rock 550 feet long, and has a fall of 3.644 feet, or .662′ per 100 feet. The best water is next the right bank, and in the right-hand island chute, where there is 3 feet. This channel is obstructed by a reef and fish-trap dam. These should be removed, and the other channel closed up. The volume of water thrown into the right-hand channel (which is about 100 feet wide) will give sufficient depth.

Estimated cost.

600 cubic yards solid-rock excavation, at $3	$1,800
Building dams of same, at 50 cents	300
	2,100

In the island chute below the shoal there are three reefs that should be removed. Between the shoal and the first and second reefs there is only 2½ feet water, but the bottom here is of loose sand, and when the reefs are removed this will wash away. One-half mile below these there is a reef of detached rocks which should be removed. From this point to Rum Creek the water is good.

Rum Creek Shoal is at the mouth of Rum Creek. It consists of reefs and detached rocks, with deep water between them. There is but little fall, and the removal of loose rock and the excavation of a channel 80 feet wide, 100 feet long, and 2 feet deep will remove all difficulty. One half mile below the shoal there is a loose-rock bar that needs deepening. Estimated cost of work on this part of the river:

Solid-rock excavation, 1,188 cubic yards, at $3	$3,564
Loose-rock excavation, 900 cubic yards, at $1	900
	4,464

Taylor's Shoal, like Falling Creek Shoal, is a succession of rock-reefs, with deep water between them. The shoal is 2,100 feet long, and has a fall of 5.732 feet, or about .272 per hundred feet. This is very equally distributed over the entire shoal, except at the head, where there is a fall of 2.6 feet in the first 200 feet. This is caused by the damming of the water at the first reef. The best channel is near the right bank. This should be cleaned out and the reefs removed. The river here is 500 feet wide, and to give sufficient water the channel should be contracted. This can be done by building a jetty from the right bank along the first reef, and thence down the shoal to the head of island No. 2 of the diagram, and closing up the passage to the right of island No. 1. This will pond the water at the foot of the shoal and reduce the current. The channel being perfectly straight, vessels can ascend without difficulty.

Estimated cost.

Solid-rock excavation, 2,220 cubic yards, at $3	$6,660
Loose-rock excavation, 1,000 cubic yards, at $1	1,000
Building jetties of same, at 50 cents	1,110
	8,770

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Between Taylor's Shoal and Harris's Shoal the water is deep and the channel unobstructed, except at *Bowman's Reef*, where it needs widening, and at Bowman's Landing, where some detached rocks should come out.

Estimated cost.

Solid-rock excavation, 100 cubic yards, at $3	$300
Detached-rock excavation, 200 cubic yards, at $2	400
	700

Harris's Shoal is like Taylor's Shoal. It is 3,000 feet long and has a fall of 2.312 feet. At the first and second reef the channel should be widened 50 feet. Upon the lower ledge, for 600 feet, there is only 3 feet water. Here the channel, which is now 300 feet wide, should be contracted.

Estimated cost.

60 cubic yards solid-rock excavation, at $3	$180
Removing 300 yards loose rock, at $1	300
Building jetties of same, at 50 cents	150
	630

Between Harris's and Johnston's Shoals no work is needed.

At *Johnston's Shoal* the river widens out very much, the channel being divided by three small islands. The shoal is 1,500 feet long, and has a fall of 5.125 feet, or .341' per hundred feet. This fall is very equally distributed. The reef which forms the upper part of the shoal has 2 feet of water on it, and this deepens to 3 feet and 2.5 feet, the channel being greatly obstructed by loose rock. At the lower end of the first island there is a fish-trap dam, and 400 feet below this a rock-reef. Channels should be cut through these reefs and the loose rock removed. All the channels should be closed except that next the right bank, and this should be contracted by a jetty from the first reef to the fish-trap dam. Jetties 6 feet high should be placed 500 feet below the last reef. This will give a good channel over the shoal and make the passage of it easy.

Estimated cost.

Solid-rock excavation, 100 cubic yards, at $3	$300
Loose-rock excavation, 1,000 cubic yards, at $2	2,000
Building jetties of same, at $1	1,000
	3,300

The next obstacle is called *Holman's Shoal*. This consists of two rock-bars 500 feet apart. The first bar is 200 feet long and has 2 feet of water on it. The second bar has 5 feet of water, but needs widening.

Estimated cost.

1,300 cubic yards solid-rock excavation, at $3	$3,900

Passing below this shoal, we have deep water, free from obstructions, until near the head of *Wimbush's Island*, where two reefs cross the river, leaving deep channels but not sufficiently wide. Two hundred feet below the head of the island, in the right-hand channel, is another reef, with 1 foot of water on it. Three hundred feet below this there is another reef. These obstacles should be removed, and the left-hand channel at the head of the island closed.

Estimated cost.

Removing 210 cubic yards solid rock, at $3	$630
Building dams with same, at 50 cents	105
	735

At the foot of the island is *Holt's Shoal*, also called Wimbush's Shoal. This is a rock-bar 400 feet long, upon which there is 2 feet water, but greatly obstructed by loose rock. Upon the upper edge of the bar there is a reef with 1 foot of water, and on the lower edge a reef and a fish-trap dam. These should be removed and the channel near the right bank cleaned out. A jetty should be built from the lower end of the island inclining toward the right bank and extending 500 feet below the fish-trap dam.

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Estimated cost.

Solid-rock excavation, 100 cubic yards, at $3	$300
Loose-rock excavation, 1,000 cubic yards, at $1	1,000
Building jetty of same, at 50 cents	500
	1,800

For 1 mile below this shoal there are several islands dividing the channel. The best water is next the right bank of the river, and the other channels should be closed. Seven reefs cross the channel here. The first, second, and third reefs have each 1 foot of water. The fourth reef has 2.5 feet, and the others have each 1 foot.

Estimated cost of work needed here.

Removing 570 cubic yards solid rock, at $3	$1,710
Building dams with same, at 50 cents	285
	1,995

About 500 feet below the last island there is a reef of bare rock, with an opening in it of 30 feet. This opening should be increased to 100 feet, and a jetty built from the island to the reef.

Estimated cost.

Removing 200 cubic yards solid rock, at $3	$600
Building jetty of same, at 50 cents	100
200 yards jetty, at $2	400
	1,100

This is the last of the reefs and shoals. The river here is about 300 feet wide, and for ¼ mile there is a sand-bank, upon which there is an average of 3 feet of water. About 2½ miles from this there is a similar bank. Both of these deposits occur where the current is slack and with deep water above and below them, and are probably caused by sunken trees and logs. These being removed, the banks will wash away. There is also on this portion of the river one reef to be removed and two loose-rock bars.

Estimated cost.

Sand excavation, 16,000 cubic yards, at 60 cents	$9,600
Solid-rock excavation, 100 cubic yards, at $3	300
Loose-rock excavation, 200 cubic yards, at $1	200
	10,100
This makes	574,232
Add to this 20 per cent. for contingencies	114,846
And we have a total of	689,078

The above estimate contemplates a channel-way 80 feet wide, 4 feet deep at the lowest stage of water, and with locks 200 feet long and 30 feet wide. This will accommodate vessels carrying 300 tons for nine months in the year, and half that tonnage for the remaining three months. And we should bear in mind that during the season of low water, which occurs between the 1st of July and the middle and latter part of September, but little freight is moving, and consequently this reduction of tonnage will not be felt as an inconvenience.

From the 1st of October to the 1st of July the lowest stage of water is from 3 to 4 feet above the extreme low point, giving a minimum depth of from 7 to 8 feet.

The estimated cost of making this improvement is, then, according to the statement above given, as follows, not including contingencies and superintendence:

Bridge, Merriwether's, Hendrick's, and Crew's Shoals	$22,700 00
Cedar Shoal	100,936 00
Hanson's Shoal	39,600 00
Dried Indian Shoal	21,400 00
Flat Shoal	9,400 00
Webb's Shoal	9,400 00
Lee's Shoal	15,400 00

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Indian Fishery	$25,800 00
Barnes's Shoal	26,900 00
Reefs below	6,335 00
Lemon's Shoal	1,890 00
Key's Ferry	900 00
Harvey's Mill	4,500 00
Leverett's Shoal	1,023 00
Cap's Shoal	21,150 00
Lloyd's Shoal	102,400 00
Reef below	270 00
Pitman's Shoal	5,575 00
Roach's Shoal	7,500 00
Lamar's Shoal	1,150 00
Seven Islands Shoal	52,000 00
Little Sandy Creek Shoal	399 00
Ward's Ferry	235 00
Big Sandy Creek and McArthur's Ferry	1,650 00
Head's Shoal	1,250 00
Glover's Shoal Reefs	720 00
Glover's Shoal	46,270 00
Mitchell's Ferry	705 00
Mitchell's Shoal	1,348 50
Reef below	270 00
Jarrel's Shoal	2,001 00
Clarke's Shoal	340 00
Falling Creek Shoal	1,554 00
Reef below	777 00
Reef below	200 00
Dame's Shoal	2,100 00
Rum Creek Shoal	4,464 00
Taylor's Shoal	8,770 00
Bowman's Reef	700 00
Harris's Shoal	630 00
Johnston's Shoal	3,300 00
Holman's Shoal	3,900 00
Wimbush's Island	735 00
Holt's Shoal	1,800 00
Reef below	1,995 00
Reef below	1,100 00
Sand-banks below	10,100 00
	573,405 00

The prices employed in making up this estimate are, however, too small, though they have been used in making previous estimates. Experience has shown that in conducting work on these southern rivers, the sudden and great changes of height to which their surfaces are subject renders all engineering operations in their channels so uncertain that the cost exceeds very greatly the cost of similar work in other places. In this case, the cost of rock-excavation in channel would be not less than double that assumed, while the construction of the wing-dams would cost not less than three or four times the amount estimated. Making these and other necessary changes in the prices of the various kinds of work enumerated, the estimated cost of this work would not fall short of $800,000

And adding 25 per cent. for the cost of superintendence, and to meet the contingencies to which lock and dam construction in running water is peculiarly liable 200,000

Total 1,000,000

We have $1,000,000 as the probable cost of doing this work. Of course, this is not an accurate estimate; nothing but a survey could give that, and we have been able to make only an examination.

It is to be observed, moreover, that the total fall of this part of the river, as given by the survey of 1871, before referred to, is 360 feet. The estimate before given provides for a total lockage of about 200 feet, affecting perhaps 10 miles of the river's length. The remaining 50 miles, then, would have a fall of 160 feet, an average of nearly 3¼ feet per

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mile, much too great to permit of easy or even of good navigation; and it appears quite certain that if the improvements covered by the preceding estimate were made, it would become equally necessary to carry the slack-water system up through the whole or the greater part of the remaining 160 of fall; and the total cost of the improvement of this 61 miles would be not much less, if any, than $2,000,000. A survey only can determine this, and there is nothing in the local necessities of this region which would warrant so expensive an undertaking.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

P 8.

EXAMINATION OF POWELL'S, CLINCH, AND EMORY RIVERS, IN VIRGINIA AND TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., February 2, 1876.

GENERAL: I have the honor to submit herewith reports upon the following examinations, ordered by act of Congress approved March 3, 1875, viz:

1st. Powell's River from the three forks, in Wise County, Virginia, to the mouth of Clinch River, Tennessee.

2d. Clinch River from the mouth of Indian, in Tazewell County, Virginia, to the junction of Clinch and Powell's rivers, Tennessee.

3d. Clinch River below the mouth of Emory River, and Emory River above its mouth, for the removal of bars, Tennessee.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

EXAMINATION OF POWELL'S RIVER FROM THE THREE FORKS, IN WISE COUNTY, VIRGINIA, TO THE MOUTH OF CLINCH RIVER, TENNESSEE.

By the wording of the act of March 3, 1875, it will be observed that the examination was to be extended to the mouth of the Clinch River, which is 106 miles (estimated) below the point at which Powell's River empties into it. As the same act of Congress requires, however, the examination of the remaining part of the Clinch, above the mouth of Powell's River, I have thought it best to restrict this report to the examination of Powell's River only, leaving the examination of the lower part of the Clinch to be included in the report upon that river.

From the Three Forks, in Wise County, Virginia, where the examination was begun, Powell's River runs in a southwesterly direction about 190 miles (estimated) to its junction with the Clinch; 70 miles of this length lying in Virginia, and the remaining 120 miles in Tennessee.

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The valley through which this river flows is surrounded, except to the southward, by ridges and spurs of the Cumberland Mountains, which render it almost inaccessible. It has no railroad facilities.

The river forms its only outlet, and this is narrow, crooked, and so much obstructed by bars, rocky ledges, snags, shoals, mill-dams, and fish-traps, that it requires a rain-tide of 5 or 6 feet to enable flat-boats to pass down it. It cannot be used at all during the season of low water; and during the season of navigation, which is limited to the winter and spring months, if, as sometimes happens, only two or three boating-tides occur, much of the produce of the valley is left on the farmers' hands, to their great injury.

The region watered by Powell's River and its tributaries is a very fertile one, containing some of the best farming-lands in Virginia and Tennessee, and its annual produce of wheat, corn, oats, bacon, and other farm-products is valued at over $1,000,000, independently of its timber, iron, and coal. None of this latter is shipped. Not less than 120 or 130 flat-boats, with cargoes valued at from $1,000 to $5,000, come annually out of Powell's River.

Assistant engineer William M. Gordon, who made this examination, reports that the fall in the lower part of the river is too great, and the supply of water during the summer and autumn too little, to admit of its adaptation to low-water navigation.

All that can be done, then, and all that is asked, is to so improve the high-water navigation that boats may be able to pass out on rain-tides of 3½ or 4 feet. This would increase the safety of the navigation during the higher tides, and would render available for boating many rain-tides, which, in the present condition of the river, are useless for that purpose.

This could be accomplished by breaking off the points of the ledges which project above low water, blasting and removing the large bowlders which have fallen into the channels, cutting away some points, removing overhanging trees, snags, dams, and fish-traps, and in a few cases building wing-dams for the purpose of confining the channel to narrower limits.

The estimated cost of this work is as follows, viz:

For that part of the river lying in Virginia below Shaver's Ford, (above which the character of the river forbids any attempt at improvement,) length 40 miles	$4,590
For that part lying in Tennessee, length 120 miles	15,410
	20,000
Superintendence, contingencies, &c., 25 per cent	5,000
Total	25,000

For more detailed information upon this subject reference should be made to the report of Assistant Gordon, which is hereto appended:

REPORT OF MR. WILLIAM M. GORDON, ASSISTANT ENGINEER.

Powell's River rises in Wise County, Virginia, and, following a general southwest course through Lee County, Virginia, enters Tennessee, and, either passing through or touching Hancock, Claiborne, Union, Campbell, and Anderson Counties, empties into Clinch River about 35 miles above Clinton. The principal affluents on the north are Stone Fork, North Fork, Trading Creek, Four Mile, Davis's Creek, and Cedar Creek; and on the south, Station Creek, Wallen's Creek, Mulberry Creek, and Hoop Creek. Many smaller ones come in on both sides. For properly understanding the character of the river, I will divide it into four sections, and describe them in order.

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Section I embraces that portion from the mouth of South Fork, in Wise County, to Shaver's Ford, in Lee County, Virginia, a distance of about 30 miles.

Section II includes that part from Shaver's Ford to White Shoals, in Lee County, about 28 miles.

Section III extends from White Shoals to the mouth of Hoop Creek, in Claiborne County, Tennessee, a distance of about 35 miles.

Section IV embraces the part from Hoop Creek to the junction with Clinch, in Anderson County, Tennessee, a distance of some 96 miles.

The distances, as given above, were merely estimated, the estimates being based partly on my own judgment and partly on information derived from persons living on the river. To correct any supposed error, the figures should be increased.

Beginning at the mouth of South Fork, the river for the first 6 miles is about 125 feet wide, varies in depth from 2 to 5 feet, has a moderate current, no abrupt bends, and few obstructions. We here reach Ollinger's Mill-dam, with a fall of about 6 feet. From this point a marked change takes place in the character of the river; the channel becomes contracted; the shoals and rapids are greatly multiplied, the fall being much greater; many short and abrupt bends occur, with perpendicular, jagged limestone cliffs opposite the points; great numbers of bowlders have fallen from the bluffs and lie strewn along the bed; numerous islands obstruct the water-way, dividing it into very narrow channels; and, within a distance of 25 miles, five mill-dams are met with, having an aggregate fall of 30 feet. Boats have never run on this portion of the river, as far as I could learn. The affluents are small, making it appear that the mills are a necessity in their present position. A large amount of money would be required to clear out the obstructions and build aprons to the dams, and if all other obstacles were removed, the current is so rapid and the bends so sharp that I think few persons would be found bold enough to trust their property to be carried over this part of the river. The farmers living on the upper part find ready sale for their surplus productions to the citizens of Wise, and those living lower down can easily haul their produce 8 or 10 miles to Shaver's Ford.

In view of these facts, I have not included Section I in my estimate, but have considered Shaver's Ford as the proper head of navigation.

From Shaver's Ford, the beginning of Section II, the river is still rather narrow for 8 or 10 miles; but the current is much less rapid, very few islands are met with, the bends are more gradual, and few obstacles are found. Fifteen or 20 boats leave here annually. The river gradually widens and deepens until we reach White Shoals.

At this point the river turns more to the west, and runs more nearly through the center of the valley. To the mouth of Hoop Creek it is broad and deep, with little current; the shoals have inconsiderable fall, except at a few places, notably the Bagstring and Parret's Chute; the bends are very gradual and sweeping, and for almost the entire distance we have a beautiful river.

From Hoop Creek to its junction with Clinch the river is still broad, but not so deep; the fall becomes greater than in the last section, with an almost continuously brisk current, which at times becomes rapid; the islands are more numerous and the navigation more dangerous.

Powell's River, running as it does through the mountains, is necessarily very tortuous, bends occurring at every few hundred yards, and sometimes, as at Nevel's Shoals, after running a distance of 3 miles, returns so nearly upon itself that the space across the neck is only a few hundred feet.

OBSTRUCTIONS.

In 1845 the State of Tennessee expended within her limits about $7,000 in the removal of some of the most dangerous rocks and fish-dams, and in building wing-dams at some of the islands and shoals.

A considerable amount of work was done, and the navigation was greatly improved. The boatmen in Virginia banded together a few years ago and removed some of the most dangerous obstacles, thus showing a disposition to help themselves. Still, much remains to be done. Large masses of rock have become detached from the cliffs and fallen into the river; fish dams and traps have been rebuilt in defiance of law, and the wing-dams, originally built of the round bowlders found in the river, and on too small a scale, have in most cases been entirely destroyed by drift-logs and the current.

The obstructions now found in the river may be classified as follows:

Ledges of rock running across the river, and showing sharp points above low water.

Large bowlders that have fallen from the bluffs.

Shoals of smaller bowlders and gravel.

Islands dividing the water-way into narrow channels.

Rocky points extending into the river at the bends, and mostly covered with small trees and brush.

Leaning trees and hanging limbs; snags.

Fish dams and traps.

Mill-dams.

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PLAN OF IMPROVEMENT.

The ledges of rock which cross the river in very many places are mostly limestone; some sandstone was found. These ledges have points more or less sharp, projecting above ordinary low water to the height of a foot or more, and are very dangerous; they should be broken down by the hammer and wedge, or by blasting to the low-water mark.

The large bowlders have fallen from the cliffs, loosened by the action of water and frost, and lie scattered along the whole length of the river. These should be broken up with powder, and the fragments removed to the bank, except when they fall into deep water.

The larger bowlders (those that show above ordinary low water) found on the shoals should be moved out of the channel; this can readily be done by hand. At most of the islands and some of the shoals, as at Potut's Island, Farley's Shoals, Parrett's Chute, mouth of Mulberry, Hook Creek, Nevel's Shoals, Cox's Shoals, Jack Nantz's Shoal, Island Ford, Bradin's Shoals, Baker's Tow-head, Ridenhour's Island, and Poor Horse Island, wing-dams should be built to turn the water into the boating channel.

Many of the points at the bends project into the river, lessen the water-way, and force boats to make too wide a circuit, thus rendering them liable to be thrown on the opposite bank below. Their removal would greatly lessen the dangers of navigation.

Leaning trees and hanging limbs are found at almost all the points, and on many of the stretchers, especially in the upper river. Their removal is a necessity. The trees should be felled, trimmed of their branches, and then cut up into pieces 10 feet in length, to be borne off by the tides and deposited out of the way of boats.

Snags are frequently found, especially in the lower river. Almost all persons in clearing the banks merely cut the trees, allowing them to fall with tops in the water, the butts resting on the land, and to remain in this condition until the first rain-tide swings them off. The whole trees float slowly down the stream, to be caught probably on the first shoal or in the first eddy, and form dangerous snags. These should be removed, and it should be made imperative on all persons cutting trees into the river to lop off all the limbs, and cut the trunks into lengths not exceeding 10 feet, so that, when the water rises, the parts would separate and be deposited where they could do no harm.

In the most dangerous class of obstructions must be placed fish dams and traps, generally built by irresponsible and ignorant persons having a total disregard for the rights and the safety of the property of others. The traps are often placed in the best boating channel; and being built and repaired in low-water season, boatmen have no means of knowing where they are until a fatal accident occurs. I found no less than sixty-five traps, old and new, in the navigable portion of the river. Boatmen generally prefer one of the several chutes around islands and over shoals, but it is not always possible to choose; the wind may blow them off, or an oar may break in working into the proper position to enter the selected channel, and it may then be necessary to run the other, which should be unobstructed as far as possible. Hence all dams and traps should be removed, and it should be made a penal offense for any person to build another one in any part of the river.

I found three mill-dams in partial decay, and one in repair below Shaver's Ford. The latter is attached to a saw-mill belonging to Mr. Frank Holliday, in Lee County, and has a fall of 4 feet. Mr. Holliday was not at home, but I learned the dam was erected about 1872, twenty-five years after the river was first used for boating purposes. The mill is a mere frame structure and the business moderate. I learned also that suit was brought to compel its removal, and Holliday had given bond in the sum of $5,000 to make good any loss that may be caused by its erection. No accident has occurred, for the simple reason that boatmen prefer to wait for a high tide to running any risk, as it is more than probable that should a boat be broken up on it, long and vexatious litigation would result before damages could be recovered. I saw but one man who spoke of it with favor, and he lives and does business below the dam. Of course it does not interfere with his operations. I spoke to several boatmen on this subject, and all told me they approach it at all times with dread, and thank their good fortune when it is passed in safety. There is a considerable fall just below the dam, and the water is drawn off rapidly, thus rendering it more dangerous.

I recommend its removal, for it seems to me useless to spend money on minor obstructions and leave the most serious one intact.

I would recommend that landing-places be prepared for boats every 6 or 8 miles. These landings would be a great convenience—in fact, are a necessity, for boats are sometimes lost in attempting to land at unsuitable places on the approach of night or during high winds. I would merely select some soft bank, where there is eddy-water, and remove the trees, brushes, stumps, &c., for an area of say 150 feet long by 20 feet wide. This would be ample; for as each boat arrives it could be brought to the bank, stopped, and then dropped down the stream, making room for others that might follow. In the present condition of the river, boats frequently have to stop an hour or

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two before sundown, or run after night, which is always attended with danger, to find a suitable landing-place. The cost would be a mere trifle.

COST OF IMPROVEMENT.

In estimating the cost of improvement I think it best to consider the amounts required in the two States separately.

Estimate of cost of improving Powell's River in Virginia, for high-water navigation by flat-boats, a distance of about 40 miles.

Removing ledges	$100
Removing large bowlders	580
Removing small bowlders from shoals	360
Removing rocky points, and cutting leaning trees and hanging limbs	1,000
Removing fish-dams and traps	200
Removing mill-dams	750
Removing snags	50
Building wing-dams, 500 cubic yards	1,500
Cutting trees and grubbing, for landings	50
	4,590

Estimate of cost of improving Powell's River in Tennessee for a distance of about 120 miles.

Removing ledges	$1,430
Removing large bowlders	1,320
Removing small bowlders from shoals	750
Removing rocky points, and cutting leaning trees and hanging limbs	540
Removing fish-dams and traps	280
Removing snags	250
Removing mill-dams	80
Building wing-dams, 3,520 cubic yards	10,560
Cutting trees and grubbing, for landings	200
	15,410

Summary.

Estimate of cost of improvement in Virginia	$4,590
Estimate of cost of improvement in Tennessee	15,410
	20,000
Contingencies, 10 per cent	2,000
Engineering and supervision	2,000
Total cost	24,000

RESOURCES OF THE COUNTIES CONTIGUOUS TO POWELL'S RIVER.

The country drained by Powell's River and its tributaries is rich and productive, embracing some of the finest farming-lands in Southwestern Virginia and Northeastern Tennessee. Wheat, corn, oats, bacon, and other farm-products are shipped annually in large quantities; not less than 125 flat-boats, with cargoes valued at from $800 to $5,000, come out of Powell's River every winter and spring. Pig-iron is shipped from the Cumberland Gap furnace to Chattanooga by this route. Valuable timber is found on the whole length of the river; large quantities are rafted out every year. Coal is found in abundance, but no effort has been made to ship it, in consequence of high rates of freight.

The following table is made from the census returns of 1870, and shows in part the productions of the counties along the river:

Counties.	Population.	Wheat.	Corn.	Oats.	Potatoes.	Wool.	Tobacco.
		Bush.	*Bush.*	*Bush.*	*Bush.*	*Lbs.*	*Lbs.*
Lee, Virginia	13,268	81,600	368,000	67,000	18,200	21,800	(*)
Hancock, Tennessee	7,148	22,900	204,000	41,300	13,900	13,900	9,978
Claiborne	9 321	33,900	205,000	59,000	15,000	15,300	4,897
Union	7,605	29,600	168,600	69,800	(*)	10,800	14,169
Campbell	7,445	18,400	127,000	65,200	12,500	12,000	8,569
Anderson	8,704	22,900	263,000	73,000	22,000	13,600	15,578
Totals	53,491	209,300	1,335,600	375,300	81,600	86,600	53,861

* Not given.

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From extended inquiries I am inclined to think the production of cereals has greatly ncreased in the last two or three years.

REASONS FOR THE IMPROVEMENT.

The people living in Powell's Valley are literally surrounded by mountains, except o the southward. They have the Cumberland Mountains on the west, Wallen's Ridge nd Clinch Mountains on the east, and the high watershed which divides the waters of Powell's River from those of Sandy on the north. There are no railroad facilities; wagon transportation east, north, or west is entirely out of the question, and they are bsolutely dependent on Powell's River for an outlet to market. Neither Virginia nor Tennessee is able to undertake any plan looking to the improvement of the river, and he people have helped themselves as far as they are able. In the present condition of he river 5 and 6 feet rain-tides are necessary to enable boats to make the trip down, nd the annual loss of property is something over 6 per cent. It sometimes happens hat only two or three of these boating tides occur during the season, consequently much produce is left in the country, to the great loss of farmers, for every man cannot build and run a boat. If the suggested improvements are made, boats could run out on 3½ or 4 feet tides with less danger than now threatens, the season of navigation would be prolonged, and advantage taken of a favorable market.

W. M. GORDON,
Assistant Engineer.

Major WALTER MCFARLAND,
Corps of Engineers.

EXAMINATION OF CLINCH RIVER FROM THE MOUTH OF INDIAN, IN TAZEWELL COUNTY, VIRGINIA, TO THE JUNCTION OF CLINCH AND POWELL'S RIVERS, TENNESSEE.

This report covers also the examination of the remaining part of the Clinch River, extending from the mouth of Powell's River to the Tennessee River, a distance of about 106 miles, ordered by the same act of Congress, in the clause directing the examination of Powell's River.

From the mouth of Indian Creek, which it receives from the north, in Tazewell County, Virginia, the Clinch River flows in a southwesterly direction for nearly 400 miles to its junction with the Tennessee River, 165 miles of its course lying in the State of Virginia, and 230 miles of it in the State of Tennessee.

Powell's River enters it from the north at a point about 106 miles above its mouth.

Like Powell's River, the Clinch is almost surrounded by ridges and spurs of the Cumberland Mountains, which render its valley almost inaccessible, and the general characteristics of the two streams and of the regions through which they flow are the same.

The Clinch, like Powell's River, is narrow, crooked, made up of pools and shoals, and obstructed by rocky ledges and points, bars and shoals of gravel, scattered bowlders, snags, mill-dams, fish-traps, and overhanging trees.

It has the same seasons of high and low water, the boating tides occurring only in the winter and spring months, with the same irregularity and uncertainty as in Powell's River, and with the same consequent injury to the farmers when these tides are not numerous enough to enable them to remove their entire crops.

The valley is equally fertile and rich in resources, the value of its farm-products annually exported being about $2,000,000. Over 150 flat-boats, with cargoes ranging from $1,000 to $5,000 in value, annually descend the Clinch on boating tides of 5 or 6 feet. The upper part of the river, from the mouth of Indian Creek, in Taze-

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well County, Virginia, to Nash's Ford, in Russell County, Virginia, a distance of 75 miles, is not susceptible of improvement.

Laden flat-boats have passed down from Nash's Ford to Kingston, on the Tennessee River, at the mouth of the Clinch, a distance of 320 miles; but Osborn's Ford, in Scott County, Virginia, 55 miles farther down and 35 miles by river from the boundary-line between Virginia and Tennessee, is regarded as the head of high-water navigation on the Clinch. It has no low-water navigation. No part of the river can be fitted for low-water navigation, except, perhaps, the part lying below Walker's Ferry, in Grainger County, Tennessee, 145 miles above the mouth of the Clinch. It is possible that from here to Clinton, a distance of 74 miles, a low-water depth of 1½ feet, and from Clinton to the mouth, a distance of 70 miles, a low-water depth of 2 feet, might be secured; but this question can be settled only by making a careful survey of this part of the river. At present there appears to be no necessity for any such improvement, even if it be found practicable to make it.

All that can or should be done, then, for the present, is to improve the high-water navigation of this river, so that there shall be less difficulty and danger in bringing out cargoes, and so that rain-tides of 3 or 4 feet may be made use of for boating purposes.

This can be done by breaking off the points of rocky ledges, blasting and removing the bowlders which are in the way of boats, deepening the channels over some of the bars, removing fish-traps, mill-dams, snags and overhanging trees, and contracting the channel occasionally by the use of wing-dams. This improvement should begin at Nash's Ford, and should extend to the mouth of the Clinch, 320 miles.

The estimated cost of it is as follows:

Nash's Ford to the boundary-line between Virginia and Tennessee, 90 miles ..	$14,100
Boundary-line to mouth of Clinch, 230 miles	21,120
	35,220
Contingencies, &c., 25 per cent	8,805
Total	44,025

For further information as to the examination of this river, reference may be made to the report of assistant engineer William M. Gordon, which is sent herewith:

REPORT OF MR. WILLIAM M. GORDON, ASSISTANT ENGINEER.

Having completed the field-work on Powell's River July 14, I immediately started for the mouth of Indian, in Tazewell County, Virginia, to begin the examination of the Clinch; but the floods of July occurring, it was not until the 9th of August that the river was sufficiently low and clear for the work to be commenced. The trip down the river was made in a canoe guided by two men. Clinch River rises in Tazewell County, Virginia, and flowing southwest through Russell and Scott Counties enters Hawkins County, Tennessee, and continuing the same general course passes through or touches Hancock, Claiborne, Grainger, Union, Campbell, Anderson, Knox, and Loudon Counties, and empties into the Tennessee River at Kingston, in Roane County. Its principal affluents are Indian, Bull Creek, Guest's River, Strong Creek, North Fork, Sycamore Creek, Powell's River, Poplar Creek, and Emory River on the north, and Maiden Spring Fork, Big Cedar Creek, Copper Creek, Big War Creek, and Bull Run on the south. Many smaller streams flow in from either side. For convenience of description and reference the river may be divided into four sections.

Section I includes that part from the mouth of Indian, in Tazewell County, to Nash's Ford, in Russell County, Virginia, a distance of about 75 miles.

Section II extends from Nash's Ford to Osborn's Ford, in Scott County, Virginia, about 55 miles.

Section III embraces that portion from Osborn's Ford to Walker's Ferry, in Grainger County, Tennessee, a distance of about 120 miles.

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Section IV includes the remaining part of the river to Kingston, about 145 miles.

In the upper portion of section I the river is narrow and shallow, nothing more than a large creek. Receiving the Maiden Spring Fork and other streams, it increases in size and assumes a bolder character; the fall becomes much greater, the bends very abrupt, and in many places where the river passes around the north end of Copper Ridge, the water dashes over the ledges and down the falls with the force and rapidity of a mountain-torrent, entirely precluding the possibility of safe navigation.

At Nash's Ford, which is about 6 miles north of Lebanon, the county-seat of Russell County, a great change takes place; the river becomes broad, the pools long and deep, with little current, the fall on the shoals moderate, the bends are gradual, and for 40 miles we have a fine stream. The first obstruction of any importance is "The Falls." This is a ledge of rock crossing the river at the foot of a large pool; it crosses at an angle of about 45° and has a fall of 3 feet. The current is not rapid either above or below, and the water is not drawn off rapidly. Persons living near told me that during what would be called a moderate boating-tide no great disturbance is occasioned by it. It can be easily improved for navigation. The next obstacle of importance is at Hanging Rock Falls. The river here is impeded by very large masses of rock that have fallen from the cliffs on either side; the removal of these to low-water mark would make it entirely safe, the fall being nowhere abrupt and only about 2 feet in 100 feet, with eddy-water below.

The river now becomes narrower and rougher, having Pine Ridge on the left and the Bull Creek Hills on the right. For a distance of 4 or 5 miles the pools are shorter, the fall on the shoals is much greater, the current in some places being very rapid; large bowlders are numerous, and rock-points jut out into the river, but there are no abrupt bends such as occur in the upper river, and no physical conditions exist to prevent its improvement for safe navigation. Mr. Samuel Nash, who lives near Nash's Ford, told me his father, about 1820, sent from that point two flat-boats loaded with corn to Kingston, and in 1824, when his death occurred, was preparing to build four others to make the same trip.

Several families have moved from Russell County to the West via the Clinch and Tennessee Rivers, thus showing that this portion of the river in its unimproved condition has been used with success. To Osborn's Ford the river is in good condition. The improvement of this section would give easy and cheap outlet to a large and productive portion of Russell County, now practically cut off from market. Osborn's Ford, in Scott County, is practically the head of navigation. For the first 50 miles of this section the river is generally broad and deep, with few shoals and little fall, except at "The Rounds," and over Rogers's Shoals. Then for 30 miles it passes between Copper Ridge on the left and Chestnut Ridge on the right, and is known as the 30-mile Shoal. The river through the ridges is still wide, but not so deep as above, and has more fall, but no obstacles of a serious character are found. After passing the ridges the river widens and deepens and the fall becomes less to Walker's Ferry.

From Walker's Ferry to Kingston there is the usual succession of pools and shoals; a greater number of islands is seen, but no very serious obstructions are met with.

In 1845, the State of Tennessee expended $10,000 in improving Clinch River from the State line to its mouth, but the work was not thoroughly done. Many bowlders have fallen in since or were not moved at the time, fish-traps and mill-dams have been built, the wing-walls erected have been washed away, and at present the estimated amount of money could be very profitably expended. In 1872 the legislature of Virginia granted a charter to the Clinch River Improvement Company, but gave no money. About $1,000 have been expended by the company within the limits of the State, and much good has been accomplished.

Only one mill-dam was found between Nash's and Osborn's Fords. This is at Ruin Island, about 2 miles above the latter place, and is a mere loose-rock structure. From Osborn's Ford to the Tennessee line there are two mill-dams belonging to George Craft and Claiborne Neeley, respectively. Craft's dam is located at the head of a shoal, is from 1½ to 3 feet high, and runs partly across and down the stream; it supplies water for a grist and saw mill built about thirty years ago. Business moderate. Neeley's mill is a small sash-saw affair built about four years ago. The Clinch River Improvement Company tore down a portion of the dam two years ago, but last winter a boat loaded with grain was lost by striking upon it. Suit was instituted by the owners, and the value of the boat was recovered; another suit for the recovery of the value of the grain is still in progress. This dam is very dangerous, being built at the head of a bad, rocky shoal, with considerable fall, and from which the water is drawn off rapidly. In Tennessee two small dams were passed.

The obstructions found in the Clinch are of the same character as those noticed in Powell's River.

The same classification and the same plan of improvement may be adopted, and it only remains to estimate the cost of removal.

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Estimate cost of improving Clinch River for flat-boat navigation at high water, from Nash's Ford, in Russell County, to Osborn's Ford, in Scott County, Virginia, a distance of about 50 miles.

Removing ledges	$1,970 00
Removing large bowlders	2,630 00
Removing smaller bowlders from shoals	585 00
Removing rocky points and cutting leaning trees and hanging limbs	2,660 00
Removing fish-traps and dams	80 00
Removing snags	50 00
Removing mill-dam	25 00
Building wing-dams	4,960 00
Cutting trees and grubbing for landings	30 00
	12,990 00

Estimate of cost of improving Clinch River from Osborn's Ford to the Tennessee line, about 35 miles.

Removing ledges	$10 00
Removing large bowlders	245 00
Removing smaller bowlders from shoals	75 00
Removing rocky points and cutting leaning trees and hanging limbs	10 00
Removing fish-dams and traps	30 00
Removing snags	60 00
Removing mill-dams	650 00
Cutting trees and grubbing for landings	30 00
	1,110 00

Estimated cost of improving Clinch River from the Tennessee line to Kingston, about 230 miles.

Removing ledges	$650 00
Removing large bowlders	1,200 00
Removing smaller bowlders from shoals	150 00
Removing rocky points and cutting leaning trees and hanging limbs	100 00
Removing fish-traps and dams	300 00
Removing snags	500 00
Removing mill-dams	120 00
Building wing-dams	17,850 00
Cutting trees and grubbing for landings	250 00
	21,120 00

Summary.

Estimate of cost from Nash's to Osborn's Ford, 55 miles	$12,990 00
Estimate of cost from Osborn's Ford to Tennessee line, 35 miles	1,110 00
Cost in Virginia	14,100 00
Cost in Tennessee	21,120 00
	35,220 00
Contingencies, 10 per cent	3,520 00
Engineering and supervision	2,000 00
Total cost	40,740 00

The following table, compiled from the census returns of 1870, shows some of the productions of the counties contiguous to Clinch River:

Counties.	Population.	Wheat.	Corn.	Oats.	Potatoes.	Wool.	Tobacco.
		Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Pounds.*	*Pounds.*
Russell, Virginia	11,103	41,000	206,000	56,000	9,000	27,000	17,282
Scott, Virginia	13,036	53,600	222,000	68,700	13,000	24,200	16,557
Hawkins, Tennessee	15,837	138,900	466,500	112,300	18,800	26,100	12,370
Grainger, Tennessee	12,421	78,100	153,300	86,000	20,300	16,000	16,646
Roane, Tennessee	15,622	74,800	504,600	112,000	24,400	14,000	350
Loudon, (new county)							
Total	68,019	386,400	1,552,400	435,000	85,500	107,300	63,205

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The same reasons may be urged for the improvement of the Clinch as were given in my remarks on Powell's River. Clinch Valley runs parallel with Powell's Valley, and is in like manner inclosed by mountains, and all produce must seek a market by Clinch River.

About 150 flat-boats come out of Clinch River annually, and there is a loss of about 6 per cent. from accidents. A large number of rafts are also brought down, but even an approximate estimate of the quantity of lumber produced cannot be made for want of proper data. Coal and iron abound.

W. M. GORDON,
Assistant Engineer.

Major WALTER MCFARLAND,
Corps of Engineers.

EXAMINATION OF CLINCH RIVER BELOW THE MOUTH OF EMORY RIVER, AND EMORY RIVER ABOVE ITS MOUTH, (FOR THE REMOVAL OF BARS,) TENNESSEE.

Emory River is a small stream which flows from the north and enters the Clinch River 4 miles above its mouth.

Barton's Landing, 7½ miles above the mouth of Emory River, is the head of navigation, although on very high rain-tides steamers have sometimes passed up to Emory's Gap, 4 miles above, where the Cincinnati Southern Railroad, now in course of construction, is to bridge the river. Above Barton's Landing there are numerous falls in the river. Below it there are many bowlder-bars, with from 6 to 12 inches of water over them. If the river were improved by giving it channels 60 feet wide and 2 feet deep, it would be necessary, in order to make them available, to construct a wing-dam 800 feet long in the Clinch River, below the mouth of the Emory. The estimated cost of this work would be—

Improving channels	$10,500
Wing-dam in Clinch	3,600
	14,100
Contingencies, &c., 25 per cent	3,525
Total	17 625

There appears to be no good reason for undertaking this improvement. An iron-furnace was constructed some years ago at Oakdale, with a landing on the river about 5 miles from the mouth, but it has never been used—at least, it has produced no iron.

The valley does not appear to be a very productive one, and such produce as it sends out is readily carried over good roads to Kingston, on the Tennessee, only 7½ miles distant from Barton's Landing.

No public interest demands the improvement.

For details of the examination of this river, see the report of assistant engineer W. M. Gordon, herewith.

REPORT OF MR. WILLIAM M. GORDON, ASSISTANT ENGINEER.

In connection with Clinch River, it was made my duty to examine Emory River for the removal of bars.

Emory River rises in Morgan County, Tennessee, and, flowing southeast, empties into the Clinch about 4 miles above Kingston; Little Emery is the principal affluent. Barton's store and landing, 7½ miles above the mouth, and about the same distance

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by wagon-road from Kingston, may be considered the head of navigation, as at this point there is a fall of 1 foot perpendicular, with numerous shoals and falls above. On very high tides, steamers go to Emory's Gap, 4 miles above, but the river is narrow and crooked. Such trips are not frequent. The Cincinnati Southern Railroad will cross the river at the gap.

At Cooper's Landing, 1½ miles below Barton's, is a store and hotel, with a few scattering houses. Oakdale Landing, half a mile below Cooper's, has a store-house and one dwelling. The current of Emory River below Barton's Landing is very sluggish; in fact, except at two places, it is hardly practicable. The water in the pools is from 6 to 15 feet deep. Numerous bars rise suddenly from the deep water, and as suddenly disappear. These bars are composed of rounded bowlders, from 6 to 18 inches in diamter, though near the mouth much larger ones are found. One bar is 200 feet long, with only 6 inches of water on it; another is 370 feet long, with an average of 8 inches; and others from 20 to 250 feet in length, with 1 foot of water at low summer stage.

Ledges of rock cross the river at various points, but nowhere approach the surface nearer than 2 feet, except at the mouth of Little Emery and at a point about 600 feet below. At the former place the bar is of stratified limestone, 95 feet long, extends entirely across the river, and has only 6 inches of water on it. At the latter place the bar is 140 feet long, and has a channel depth of 18 inches. My estimate of cost is based on giving a low-water channel 60 feet wide and 2 feet deep. Should greater depth be required the cost would be largely increased, as many bars and ledges not included in the present estimate would have to be considered. To enable boats to reach the mouth of Emory River a wing-wall about 800 feet long would have to be built on the shoals, below Green's Ford, on Clinch River.

Estimate of cost of improving Emory River from Barton's Landing to its junction with Clinch, and Clinch River from the mouth of Emory to the Tennessee River, to give 2 feet of water at low summer stage 11½ miles.

Removing ledges, 510 cubic yards, at $10	$5,100
Removing bars, 5,300 cubic yards, at $1	5,300
Removing rocky points	75
Removing leaning trees and hanging limbs	25
Building wing-wall in Clinch River, 1,200 cubic yards, at $3	3,600
	14,100
Contingencies, 10 per cent	1,400
Engineering and supervision	1,000
Total cost	16,500

Emory Valley does not seem to be very productive, and, from all I could learn, no great amount of produce is shipped. There has been greater activity on the river this season than usual in the transportation of supplies for the contractors on the Cincinnati Southern Railroad, but this demand is only momentary.

About 1 mile from Barton's Landing are several coal-mines, having a tram-way to the river, but no special activity was observed. Several years ago a large iron-furnace was erected about 4 miles from Oakdale Landing, but has produced no iron.

In view of the fact that the whole of Emory's Valley has easy access by wagon-transportation to Kingston and a market, and that only very limited interests are involved, I cannot recommend the improvement of Emory River.

CONCLUDING REMARKS.

In your communication of June 22, above referred to, I find the following:

"You will observe that in the instructions relating to the examination of the Hiawassee and Little Tennessee Rivers, a channel depth of 3 feet at low water is spoken of. This is the depth which is being secured for the Tennessee, and if it were possible it would be well to secure it for all the branches of the Tennessee; and this you will please bear in mind in making your examinations and report upon the possibility of securing this depth in the Clinch, Emory, and Powell's rivers, or the possibility of securing a depth of 2½ feet or 2 feet, or 1½ feet at low water. Report also on the probability or improbability of securing slackwater navigation on these rivers, and whether it is worth while to attempt a survey for this purpose."

My report on Emory River covers these points so far as that river is concerned.

The fall in the lower portion of Powell's River is too great, and the supply of water in the summer and fall too limited, for low-water navigation, and, indeed, I see no necessity for attempting to secure it.

From Walker's Ferry to Clinton a depth of 1½ feet, and from Clinton to Kingston a

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depth of 2 feet at low water *might* be secured; but this fact can only be definitely determined by an elaborate survey, involving the frequent gauging of the river and making numerous soundings on the shoals.

The accomplishment of any plan of improvement looking to this result could only be secured by a large expenditure of money, and its necessity is not apparent, though I was told that large timber used in the construction of flat-boats is becoming scarce along this portion of the river.

Clinton, the only town on any of these rivers, is connected with Knoxville by the Ohio and Knoxville Railroad. The railroad-bridge over the Clinch at Clinton is a simple Howe truss of 4 spans, two of 150 feet and two of 120 feet each. The bottom chord is about 51 feet above low water. It has no draw.

Slackwater navigation could be secured on the Clinch, but the interests involved do not seem to justify the expense, and I see no necessity for making a survey with a view to such improvement.

W. M. GORDON,
Assistant Engineer.

Major WALTER MCFARLAND,
Corps of Engineers.

APPENDIX Q.

ANNUAL REPORT OF MAJOR G. WEITZEL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 12, 1876.

GENERAL: I have the honor to transmit herewith my annual reports relating to the works of river and harbor improvements under my charge for the fiscal year ending June 30, 1876.

I am, general, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Q 1.

IMPROVEMENT OF THE FALLS OF THE OHIO RIVER.

The operations on this work during the year are fully set forth in the report of my assistant, Capt. A. Mackenzie, Corps of Engineers, who is in immediate charge of the work. The following is a copy of his report:

UNITED STATES ENGINEER OFFICE,
Louisville, Ky., June 30, 1876.

SIR: I have the honor to submit the following report of operations on the improvement of the Falls of the Ohio River and enlargement of the Louisville and Portland Canal, for the fiscal year ending June 30, 1876.

During the year 1874, though the water was low and very favorable for work, but little progress was made, owing to the small amount of money available. During the past year even less has been accomplished, the continued high stage of the river having prevented a successful prosecution of the work. The work proposed at the beginning of the year was as follows: To complete the rock excavation at the head of the Louisville and Portland Canal; to complete the cross-dam at the head of the falls,

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leaving an opening of 600 feet on the Indiana side and making a new opening of 400 feet at the head of the middle channel; to close 400 feet of the Indiana opening and the entire middle opening with Chanoine wickets, thus leaving openings in the dam of 1,000 feet during high water, and closing these openings to 200 feet during low water; to place a movable dam at the head of the canal to assist in flushing out the river-deposit; to build new guard-gates for the new locks and for the head of the canal; to raise the masonry around the gate-recesses of the middle gates of the new locks, thus allowing the canal to be used with a higher stage of water; to improve the Indiana channel on the falls by removing the worst obstructions.

Excepting the removal of 600 yards of rock, no work was accomplished during the past year. During the coming year as much of the above-mentioned work will be finished as the funds available and the stage of the river will permit.

In July, 1875, in anticipation of low water, all machinery was gotten ready for commencing operations, but a rise in the river suspended work. In August, usually considered a low-water month, the river was higher than it had been during the same season of the year for thirty years.

During September a little work was accomplished, but high water again interfered, and it was not until October that operations could be in reality commenced.

On October 27, after the coffer-dam surrounding the rock to be excavated had been made tight, the interior pumped out, and the rock stripped ready for drilling and blasting, the barge Citizen ran into the coffer-dam with great force, breaking in 100 feet, and injuring an additional 84 feet. A cross-dam was immediately built, shutting off a portion of the interior, and repairs of the broken dam were commenced, but more high water prevented the completion of repairs, and after removing 600 cubic yards of rock all work was suspended.

During October work was commenced on the extension of the dam at the head of the falls, but high water and cold weather caused a suspension before anything was really accomplished.

This closes the description of a most unfortunate season's work. Though the condition of the river was very unfavorable, much more would have been accomplished had it not been for the damage done by the barge Citizen. I reported all the detailed facts connected with this damage at the time of its occurrence, and suggested that the matter should be referred to the United States district attorney for investigation. In January last I was notified that instructions had been sent to Mr. C. G. Wharton, United States district attorney, to examine into the question of damage, but as yet I have heard of no action being taken.

During the past year the following work was accomplished:

Coffer-dam built and filled	594 feet.
Coffer-dam repaired and filled	221 feet.
Coffer-dam partially built	184 feet.
Rock removed	613 cubic yards.

The cost of the work accomplished has been greater than during previous years, but will, I think, still fall below the prices proposed by contractors when the work was advertised. There has been expended, excluding office-expenses, commutation, &c., and including all labor, cost of material, &c., $7,894.94. Of this amount $336 was paid for work on the cross-dam, and $3,637 was expended for work on the coffer-dam previous to October 27, leaving, as the actual cost of rock excavated, $3,921.94. All the work so far done on the improvement is in good condition excepting the Sand Island dam; the damage to coping, &c., referred to in my last annual report, has increased, and in time the greater portion of the dam will be destroyed by ice, &c. The riprap work at the head of Sand Island stands very well. Sand Island continues to change its form, increasing during high water and washing away during low water, making additions to the obstructions to navigation just below, known as Portland Bar.

The earthen banks of the enlarged canal stand very well, though the Bermuda grass planted for their protection was entirely killed by the cold winter of 1874 and 1875. The slopes are now covered with ordinary grass. An osage-orange hedge has been planted the entire length of the canal, and in time it will replace the fence which now protects the banks. It is to be hoped that the coming season will be favorable for work, and that the rock-excavation as well as the cross-dam can be completed. When this is accomplished the entrance to the canal will be much improved and the stage of water will be better during seasons of a low river.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

Major G. WEITZEL,
Corps of Engineers.

There remains little for me to say in addition to that which is said in the above and that which I said in my last annual report on this sub-

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ject. We were prevented from executing the plan of operations by an unprecedented season of continued high water. As Captain Mackenzie states, several attempts were made to commence work, but they were frustrated by rises in the river. A great damage to the season's work was done by the barge Citizen, in the manner stated by Captain Mackenzie. I recommended proceedings against her. These were ordered, and I do not know why there should be any delay. This is probably better understood by the law officers of the Government than by us. No blame for any of these misfortunes can attach to Captain Mackenzie or any of my employés under him; they have done all they possibly could. It would be the most extravagant folly to carry on any of the small amounts of work that still remain to be done here during a high stage of the river. It is only the finishing-up of a project which placed the enlarged canal and new locks in practical operation over four years ago. It is contemplated to complete all the work that still remains to be done during the present season; but it is impossible to state the probable progress that will be made, as this will depend entirely upon the stage of the river.

The reason why this work has cost more than the original estimate was given by me in my annual report for the fiscal year ending June 30, 1874. The excess in cost is entirely due to the manner in which the appropriations were made. If these had been made as I recommended, I am certain that I could have built the work in three good seasons, and at a cost less than my estimate.

The original estimate for this work, as stated in my annual report for the fiscal year ending June 30, 1870, was $1,243,500. There has been allotted and appropriated for it as follows:

1868, allotted	$85,000
1869, allotted	178,200
1870, appropriated	450,000
1871, appropriated	250,000
1872, appropriated	300,000
1873, appropriated	100,000
1875, appropriated	100,000
Total	1,463,200

Of this amount $1,373,450.70 has been expended.

No additional appropriation is required for the next fiscal year.

The work is located in the third collection-district of Kentucky. The nearest port of entry is Louisville, Ky.

The amount of revenue collected at this port during the fiscal year was $56,334.96.

The commerce and navigation of the Mississippi River and all its branches will be benefited by the completion of this work.

Money statement.

Amount available July 1, 1875	$102,459 32
Amount expended during fiscal year ending June 30, 1876	12,710 02
Amount available July 1, 1876	89,749 30

Q 2.

SUPERINTENDENCE, MANAGEMENT, AND REPAIR OF THE LOUISVILLE AND PORTLAND CANAL.

On the 1st of last January I made my second special report on this work, in order to enable the honorable Secretary of War to comply with

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the provisions of section 3 of the act of Congress approved May 11, 1874, entitled "An act providing for the payment of the bonds of the Louisville and Portland Canal Company."

In this I gave a complete *résumé* of the work since it passed into our hands, at the risk of repeating all that I had said in my two previous reports. As it will undoubtedly be printed and added to this as a part, I will not repeat anything said therein excepting to renew my recommendation that the sum of $50,000 be loaned the work by the Government, to be repaid from the tolls when a sufficient surplus has accumulated. This sum is needed to place everything that is necessary in working the canal, such as machinery, gates, dredges, &c., at once in a first-class condition, and thus allow us to operate more expeditiously and economically. I also respectfully renew the recommendation contained in my last report, that barges which paid full toll when going down loaded should only pay 5 cents per ton when empty on the return trip.

In consequence of the continued navigable condition of the river during the year, the canal has been much in use, and receipts have exceeded the expenditures $18,836.16.

There have been few complaints during the year on account of delays in getting through. Some of these delays were unavoidable, and would occur even with two canals, or with the present canal again enlarged. Whenever the river rises at certain times to a certain point, there is a great rush of coal-tows and other craft down stream, and delays are unavoidable. But most of these delays are due to the fact that my employés have not the power which they should have, because the rules and regulations for the government of the canal and those using it which I have repeatedly recommended have not been enacted into a law. My assistants are almost entirely unable to regulate and control matters when there is a rush until this is done. In the mean time they are occasionally blamed for these delays, when they are entirely helpless. I am glad to be able to say that such complaints never come from persons who have any real interest in the matter.

Financial statement for fiscal year ending June 30, 1876.

Months.	Deposits. Amount.	Months.	Expenditures. Amount.
1875—July	$2, 990 96	1875—July	
August	3, 196 50	August	$7, 603 12
September	3, 899 67	September	3, 693 51
October	3, 044 32	October	3, 821 91
November	8, 452 40	November	4, 066 17
December	11, 424 32	December	7, 138 96
1876—January	2, 953 47	1876—January	3, 551 53
February	1, 302 51	February	8, 995 98
March	7, 654 02	March	3, 894 48
April	9, 630 92	April	435 10
May	15, 305 01	May	7, 704 78
June	8, 248 54	June	9, 030 94
Total	78, 102 64	Total	59, 966 48

Cash on hand July 1, 1876, $28,017.19.

From Captain Mackenzie's report, which is annexed hereto, it will be seen what has been done during the year. The policy of gradually improving and renewing the working appliances of the canal as the tolls accumulate has been strictly adhered to and with the finest results.

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There has been a very marked change for the better in the whole appearance and condition of the work and a very vast one in the system and regularity of its management.

REPORT OF CAPTAIN A. MACKENZIE, CORPS OF ENGINEERS.

LOUISVILLE AND PORTLAND CANAL OFFICE,
Louisville, Ky., June 30, 1876.

MAJOR: I have the honor to submit the following report on the superintendence, management, and repair of the Louisville and Portland Canal for the fiscal year ending June 30, 1876.

During the past two years reports have been rendered semi-annually giving in detail the condition of the canal and recommending certain extensive repairs and improvements, but it was not until near the close of the last calendar year that the surplus fund had sufficiently accumulated to justify any large expenditures.

Since that time much work has been done, and the dredging department as well as other necessary accessories of the canal are being rapidly placed in perfect working-order.

With the exceptions hereafter mentioned, the present condition of the various portions of the canal is the same as reported December 31, 1875.

The following is a summary of the work of the past year: 3,233 boats have been passed through the locks and 103,602 cubic yards of sediment have been removed by the dredges.

The mechanics have been constantly employed repairing gates, boats, bridges, machinery, &c.; building shops, putting up engines and machines; making chains, straps, and bolts for gates, and generally assisting in the extensive repair of dredging apparatus.

The lock hands have been employed passing and docking boats, cleaning off gates and walls, grading grounds, making concrete for and building foundations, repairing mitre-sills, storing lumber for new gates, planting hedges, putting up line of telegraph, watching and caring for property, and assisting the mechanics in their various works of repair and improvement.

The dredge and steamboat forces have in addition to their regular duties been occasionally employed at the locks and have assisted in repairing steamboat-dredges and mud-scows.

Under the head of permanent repairs and improvements the following work has been accomplished.

The mud-scows have been enlarged and thoroughly repaired. They will now hold 38 cubic yards each, and, though their capacity has been doubled, they are much more easily managed than formerly, on account of their superior form of construction.

A new hull for the tow-boat Walker Morris, built by James Howard & Co., of Jeffersonville, Ind., was completed and launched February 19, but the high stage of the river and constant deposit of sediment prevented the dismantling of the old boat until June 3. Since that time all machinery has been transferred and thoroughly repaired. The new boat is larger and much stronger than the old one. It will be fitted out with force and wrecking pumps, and be ready at any time to render assistance in case of a fire or the sinking of a vessel in the canal.

One dredge has been thoroughly repaired, and machinery added for raising and lowering spuds, thus enabling us to reduce the force previously employed. It is expected that the dredge in its comparatively new condition will do more work, and do it more rapidly, than formerly. Timber has been obtained for rebuilding a second dredge.

A large addition to the carpenter-shop has been built for a machine-shop, and an engine and boiler have been set up. The shop at present contains one circular and one swing saw, a bolt and screw cutting machine, and a drill-press. A 50-foot planer and lathes will soon be added. It is expected that almost the entire cost of this machinery will be saved during the coming year in ordinary repairs and the construction of new gates.

A large fire-cistern, holding 500 barrels, has been built, and a force-pump connected with it. As an additional precaution against the danger of fire, an alarm-box has been placed at the locks, and in case our own means are not sufficient a steam fire-engine can be obtained in about five minutes. A telegraph line, 2 miles in length, has been established between the head and the foot of the canal. A submarine cable is laid across the canal at the locks, and the line in the vicinity of the office is placed in a trough under ground.

An osage-orange hedge has been planted the entire length of the canal. It will in time replace the wooden fence which now protects the earthen slopes.

The ground in the vicinity of the dry-dock has been graded, and permanent ways put up for the building and launching of boats, gates, &c.

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Complete maps and abstracts of title of the canal property have been obtained; its metes and bounds are now known, and corners will be marked as soon as possible.

During the coming year the following work will be done, provided the surplus on hand, after reserving a sufficient amount for operating expenses during low water season, will justify it.

Dredge No. 2 and mud-scow No. 4 will be rebuilt; new guard-gates for the head of the canal and for the new locks, and new lift and guard gates for the old locks, will be built; the mitre-sill of the lower gate of the old locks will be repaired; a coal elevator, with capacity of 1,000 tons, and an office for the superintendent, will be built.

Additional experience is constantly developing necessary changes and improvements, and it is probable much other work will suggest itself during the year.

The surplus funds have been and still will be applied to the permanent repair of working parts of the canal, and to such improvements and additions to machinery as will promote the efficiency of management and eventually reduce the annual operating expenses.

When all the necessary repairs are completed more attention will be given to a radical improvement in the methods of working gates and bridges. Many plans for this work have been already considered, and some definite plan will be recommended as soon as money is available for such improvements.

Attention has also been given to the important question of removing river-deposit. I am still of the opinion that the present method of dredging alone gives promise of certain success, though the accessory plans of sluicing the canal, stirring up sediment in locks by filling through side culverts, and sinking catch-basins in the bottom of the locks above mitre-sills to remove deposit from the front of the gates, will assist in the work.

During the past year the river has been high, and in consequence a great number of boats have used the canal. The receipts have been much larger than was anticipated, amounting in all to $77,976.52. During May the receipts amounted to $14,927.99, being greater than for any single month during the two years of Government management. On May 27, 4 steamboats and 46 barges, with an under-tonnage of 16,979 tons and carrying about 800,000 bushels of coal, passed through the locks. The tolls for this day amounted to $1,384.60.

The continued high water deposited much sediment in the canal and locks. The rise of August, 1875, and January, 1876, left deposits in the lower chamber of the new locks of 11 and 7 feet respectively.

The rates of tolls remained as fixed by the Secretary of War January 25, 1875. A recommendation made in December, 1875, to reduce tolls on empty barges on a return-trip from 8 cents to 5 cents per ton was not acted upon.

During the past few months the number of employés has been slightly reduced, and it is hoped further reductions can soon be made. Some of the busy periods of the past year, especially heavy coal runs, have shown conclusively that a time will come when the capacity of the canal will not be sufficient for the river commerce, or that at least delays will be of so frequent an occurrence as to cause great annoyance and heavy losses. It is more than probable that the canal must in the future receive a second enlargement, and even at the present time extensive basins at the head of the canal, at the head of locks, and below the canal, are much needed.

None of the recommendations made in my report of December, 1875, have yet been acted on, and I therefore renew them, and ask that they be considered a portion of this report.

I append tables giving details of expenditures and receipts, number and tonnage of boats, and other statistical information.

In conclusion, I would state that the officers of the canal have during the past year performed all their duties faithfully and well.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

Major G. WEITZEL,
Corps of Engineers.

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Detailed statement of boats passed through the Louisville and Portland Canal for the fiscal year ending June 30, 1876.

Date.	Steamboats.		Barges.				No. of small boats.
			Model.		Square.		
	No.	Under-tonnage.	No.	Under-tonnage.	No.	Measured tonnage.	
1875.							
July	46	15,945	25	6,859	31	6,232	1
August	50	13,998	34	8,055	62	13,897	1
September	101	21,578	34	8,132	49	6,877	7
October	108	20,205	26	5,905	36	4,714½	20
November	106	27,436	78	18,020	212	43,605	25
December	81	26,001	47	11,666	269	92,407	4
1876.							
January	40	14,494	21	5,567	39	10,689	6
February	20	7,195	14	3,816½	12	2,570½	2
March	67	21,360	37	9,027	172	55,819	6
April	96	29,106	52	13,656	249	71,965	13
May	138	43,352	91	22,225	365	102,100½	11
June	129	38,446	67	16,465	127	30,479	6
Total	982	279,116	526	129,393½	1,623	441,355½	102

Detailed statement of receipts of the Louisville and Portland Canal for the fiscal year ending June 30, 1876.

No.	Designation.	Number of tons.	Price per ton or boat.	Amount.
982	Steamboats	279,116	10 cents per ton	$27,911 60
526	Model barges	129,393½	10 cents per ton	12,939 35
1,623	Square barges	441,355½	8 cents per ton	35,308 46
102	Small barges and steamers		$5 per boat	510 00

Total receipts from tolls	$76,669 14
Receipts from rents	431 15
Receipts from towage	455 00
Receipts from dry-dock	420 96
Total receipts	77,976 52

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Detailed statement of expenditures for superintendence, management, and repair of the Louisville and Portland Canal for the fiscal year ending June 30, 1876.

Date.	Superintendence, management, and ordinary repairs.											
	Lockage department.						Dredge department.					
	Regular labor.	Extra labor.	General purchases.	Repairs.	Lights.	Total lockage dept.	Regular labor.	Night work.	Repairs.	Fuel.	General purchases.	Total dredge dept.
July, 1875	$2,310 00	.....	$35 51	$53 27	.....	$2,398 78	$1,020 00	.....	$18 25	$300 00	$11 39	$1,349 64
August, 1875	2,310 00	.....	85 85	.....	$11 10	2,406 95	1,020 00	$182 00	125 63	126 00	64 12	1,517 75
September, 1875	2,310 00	.....	70 40	.....	16 10	2,396 50	1,020 00	363 51	.....	296 50	65 15	1,745 16
October, 1875	2,310 00	$11 67	31 96	.....	16 85	2,370 48	1,020 00	.....	19 93	312 00	9 80	1,361 73
November, 1875	2,310 00	177 75	77 01	225 41	8 84	2,799 01	1,020 00	.....	108 76	252 00	14 80	1,395 56
December, 1875	2,310 00	192 83	56 04	65 40	7 92	2,632 19	1,020 00	.....	244 05	398 00	79 86	1,741 91
January, 1876	2,310 00	94 37	36 30	487 15	7 84	2,935 66	1,020 00	67 16	236 25	60 00	.....	1,383 41
February, 1876	2,310 00	46 33	77 51	5 48	.....	2,441 32	1,020 00	.....	1 75	200 00	12 30	1,234 05
March, 1876	2,310 00	60 00	30 25	106 30	14 83	2,521 38	1,020 00	67 14	44 37	.....	6 37	1,137 88
April, 1876	2,310 00	34 00	44 95	2 65	1 50	2,393 10	1,020 00	8 00	6 79	450 00	8 64	1,493 43
May, 1876	2,275 00	58 50	40 84	11 65	8 16	2,394 15	1,020 00	62 00	.....	190 00	15 33	1,287 33
June, 1876	2,195 00	.....	90 57	27 35	7 68	2,320 60	1,020 00	15 34	.....	.....	99 65	1,134 99
Total	27,570 00	677 45	677 19	984 66	100 82	30,010 12	12,240 00	765 15	805 78	2,584 50	387 41	16,782 84

Date.	Permanent improvement and repairs.							Abstract of title to L. & P. Canal property.	Grand total.
	Carpenter shop.	Repair of steamer.	Machine shop.	Miscellaneous.	Repair of dredge.	Repair of mud-scows.	Total permanent improvement.		
July, 1875	.....	.....	.....	.....	.....	$68 90	$68 90	.....	$3,817 32
August, 1875	.....	.....	.....	.....	.....	61 10	61 10	.....	3,985 80
September, 1875	.....	.....	.....	.....	.....	32 09	32 09	.....	4,173 75
October, 1875	$42 23	.....	.....	.....	.....	7 65	7 65	.....	3,782 09
November, 1875	.....	.....	.....	.....	.....	105 20	105 20	.....	4,299 77
December, 1875	.....	$1,530 95	.....	.....	.....	559 89	2,090 84	.....	6,464 94
January, 1876	.....	.....	.....	$384 43	.....	634 08	1,018 51	.....	5,337 58
February, 1876	42 23	3,041 60	.....	.....	.....	27 95	3,111 90	.....	6,787 27
March, 1876	117 61	.....	.....	95 00	.....	10 37	222 98	.....	3,882 94
April, 1876	.....	.....	$150 00	33 75	.....	100 00	292 75	.....	4,179 28
May, 1876	.....	53 98	275 48	.....	.....	151 75	481 21	.....	4,102 69
June, 1876	.....	130 35	270 17	329 63	$1,908 01	.....	1,938 16	$3,000 00	8,393 75
Total	202 19	4,756 88	704 65	842 81	1,908 01	1,758 96	9,473 82	3,000 00	50,966 48

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REPORT OF JANUARY 1, 1876.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., January 1, 1876.

GENERAL: In accordance with your instructions, and to enable the honorable Secretary of War to comply with the provisions of section 3 of the act of Congress approved May 11, 1874, entitled "An act providing for the payment of the bonds of the Louisville and Portland Canal Company," I have the honor to submit the following report on the superintendence, management, and repair of the Louisville and Portland Canal for the calendar year ending December 31, 1875.

At the risk of repeating almost everything that was said by me in my reports on this subject, dated respectively January 1 and June 30, 1875, and which are printed in the annual report of the Chief of Engineers for 1875, as Appendix Q_2, I directed my assistant in immediate charge of the work, Capt. A. Mackenzie, Corps of Engineers, to make a full and complete report on the subject, as if no previous report had been rendered. His report is annexed hereto, and forms a part of this. It is so complete that little remains to be said by me. It will be seen that the period from June 11, 1874, (the date on which the canal passed under the control of the Government,) until December 31, 1874, was an exceedingly bad one for navigation, and, correspondingly, for the revenues of the canal. The deficit during this period amounted to $5,022.13. But during the past year the river has been almost continually at a good boating-stage, and the receipts exceeded the expenditures $20,416.13. The receipts from June 11, 1874, to December 31, 1875, therefore exceed the expenditures by $15,655.53.

From these facts it is evident that, not having experience of average years, we are still unable to recommend fixed rules and rates of tolls, and we need the experience of one or two more years to do this.

The main thing which is needed on this canal is, to get the tow-boat, dredges, mud-scows, &c., that is to say, the *tools* with which the canal is operated, in first-class condition. It would have been economical to have done so a year ago, but Congress failed to act on the recommendation contained in my report of January 1, 1875, that the sum of $50,000 be loaned the canal to do this; the loan to be repaid as soon as the revenues would permit it. As a consequence, we have been compelled to get along as well as we could, patching up here and there, and rebuilding only when we had the money to spare. In this way two new mud-scows have been built, the tow-boat is undergoing complete repairs, and the other tools have been kept in a partially serviceable condition.

I sincerely hope that the sum of $50,000, as recommended a year ago, be loaned the canal, in order that we may at once place everything in good working-order. It will be economy for the canal, and will save the commerce of the river a great deal of delay and consequent loss.

As will be seen by Captain Mackenzie's report, the two greatest difficulties in this canal are the immense accumulations of mud and the weight of the gates. We have all bestowed much study upon this, and if the stage of water next season permits, we intend, as it has received your sanction, to place a movable dam at the head of the canal, and on proper occasions flush it by this means. But, as Captain Mackenzie says, this will only be an important auxiliary. Two new dredges of the most modern and approved construction are imperatively needed to replace the two old and almost worn-out ones that we are now compelled to use. With regard to the gates, we believe that we will be able, as

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soon as the present ones become unserviceable, to replace them by lighter ones of equal strength.

The walls of the old locks are in considerable decay, but I believe that they will last during the life of new sills and gates; and we desire, as soon as possible, to rebuild the latter, so that in times of a coal-rush both locks can be used to advantage at the same time. With regard to the rebuilding of the north wall, the enlargement of the dry-dock, and the rebuilding of the old locks, I can only say, as I did before, that these are question for the future.

The canal since it has been under the control of the Government has been faithfully, honestly, and economically managed and entirely in the interest of commerce by my assistants and employés. There have been a few complaints, but most of them were false, and nearly all instigated, I believe, by parties who are anxious to get hold of the management.

Captain Mackenzie has omitted to state what is done with the money which is collected. As the collector's office is about 3 miles from the Government depository, the money is deposited only when it reaches the sum of $100. If the daily receipts equal or exceed this sum the deposits are made daily. A receipt is taken and the work credited with the amount, and all checks in payment of indebtedness are drawn against these deposits. I make my money-returns, papers, &c., for it precisely as for any other money under any appropriation, and under the title of "superintendence, management, and repair of Louisville and Portland Canal."

When the daily receipts do not amount to $100, the money is kept in a safe in the collector's office; and this office being a part of the collector's residence, the money is as safe as it is possible to make it.

The suggestion made by Captain Mackenzie, that a number of small plain residences be built near the locks for the use of the lock-hands, is an excellent one, and as soon as we get the necessary funds I will ask your approval of the project.

I agree with Captain Mackenzie, that the question of the right of the city of Louisville to obstruct the entrance to the canal, by permitting vessels to lie at its wharf below Sixth street, should be referred to a proper legal tribunal.

Captain Mackenzie enumerates certain things that ought to be done during the present year. We have already authority from you to do several of them, and all are necessary. I therefore repeat that it is of the first importance that Congress should authorize the Treasury Department to loan us $50,000 for the "superintendence, management, and repair" of the canal; this sum to be returned from time to time, as the receipts will warrant it.

The reasons given by Captain Mackenzie for not reducing the rate of tolls during the present year, except in case of returning empty barges, which paid toll going down loaded, are sound, and I therefore respectfully recommend that the present rate of tolls remain unchanged during this year, excepting that barges which paid toll when loaded shall only pay 5 cents per ton, when empty, on the return trip.

I desire, also, respectfully to urge the importance of enacting a law for the government of the canal, which will embody the rules and regulations which are recommended by Captain Mackenzie.

The following is the financial statement of the work for the calendar year ending December 31, 1875:

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Financial statement for calendar year ending December 31, 1875.

Deposits.		Disbursements.			
Months.	Amount.	Months.	Salaries.	Fuel, supplies, and repairs.	Amount.
January	$3,141 25	January	$3,330 00	$389 83	$3,719 83
February	1,860 68	February			
March	1,939 50	March	3,330 00	699 91	4,029 91
April	10,087 70	April	10,015 00	580 73	10,595 73
May	12,899 64	May	6,728 00	107 12	6,835 12
June	7,551 71	June	3,330 00	1,385 23	4,715 23
July	2,990 96	July			
August	3,196 50	August	6,842 00	961 12	7,803 12
September	3,899 67	September	3,693 51		3,693 51
October	3,044 32	October	3,341 67	480 24	3,821 91
November	8,452 40	November	3,625 75	440 42	4,066 17
December	11,424 32	December	3,522 83	3,616 13	7,138 96
Total	70,488 65	Total	47,758 76	8,660 73	56,419 49

Cash on hand December 31, 1875, $15,665.53.

I am, general, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF CAPTAIN ALEXANDER MACKENZIE, CORPS OF ENGINEERS.

OFFICE OF LOUISVILLE AND PORTLAND CANAL,
Louisville, Ky., December 31, 1875.

MAJOR: In accordance with your instructions I have the honor to submit the following report upon the present condition of the Louisville and Portland Canal, with such statistical information as may be of importance in determining upon future management and in fixing a rate of tolls for the coming year:

PRESENT CONDITION OF CANAL AND ACCESSORIES.

There has been no surplus fund available during the past year for permanent repairs or improvements, and the following details are in many cases a repetition of previous reports:

NEW LOCKS.

With exception of the guard-gates all parts of the new locks are in a serviceable condition. The coping of the walls is of soft stone, and has been injured in several places. The water has found its way under the miter-sills, washing out the concrete, thereby causing some of the stones to settle, but they will probably remain secure for several years. In time new sills, built of harder stone, and sunk to the solid rock, will be necessary.

The lift-gates are moved with difficulty on account of their great weight and the sediment continually being deposited in front of them. No plans have yet been perfected for moving these gates by steam or water power; and the trial of horse-power has not been made.

During high stages of the river the middle gates are flooded before the amount of water on the falls is sufficient for all ascending boats. A plan for obviating this difficulty at a small expense has been approved.

The method of filling and emptying the lock-chambers through the gates has proved a very slow one; but as shown in previous reports any change in the system would be an expensive operation.

OLD LOCKS.

These locks have been previously reported unsafe; and, although kept serviceable during the year by constant work, they are really beyond repair. Two sets of lift-gates

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are rotten, and unless it is determined to remodel the entire work, they should be replaced immediately. The lower miter-sill is in very poor condition, but can only be economically repaired during low water.

BRIDGE OVER THE OLD LOCKS.

This bridge was, for sake of economy, improperly located, and when the locks are rebuilt it should be removed.

DRY-DOCK.

The dry-dock is now in a serviceable condition, but it will only accommodate small boats, and its gates are so low that they are frequently under water. The present size of this dock is sufficient for all canal purposes, but its enlargement would be of great benefit to the river interests.

CANAL BUILDINGS AND SHOPS.

The toll-collector's house and blacksmith's shop are in good condition. During the year a carpenter-shop and tool-house have been built. Such simple machinery as will enable our own mechanics to make all repairs should be added to the shops. An office for the superintendent has not yet been built.

The hands must be housed near the locks, and when means are available it will be well to put up a few cottages to replace the old unhealthy building which they now occupy. A reasonable rent can be collected, and will pay for the outlay.

A coal-elevator, with a capacity of 1,000 tons, would permit the purchase of fuel by the boat-load, and reduce the prices now paid materially.

ENLARGED CANAL.

The condition of the enlarged canal is good. Its north bank is protected by a stone wall and riprap, at present in a serviceable condition; but in the future a new wall must be built. The south bank is protected by a new stone wall founded on the solid rock. The earth-slopes are in a very good condition, and have required but slight repairs during the past year.

GUARD-GATES AT HEAD OF THE CANAL.

These gates are rotten and unserviceable.

LIGHTS FOR CANAL AND LOCKS.

Some change in the method of lighting the canal and locks for night-work was suggested in last report; but consultations with the captains and pilots of many steamers indicate that no change is required at present.

TELEGRAPH ALONG CANAL.

Authority has been granted to connect the head and the foot of the canal by a line of telegraph, and the work will be done early next year.

CANAL-LANDS.

No deeds or information as to the boundaries of the property pertaining to the canal were received from the former management. The question was referred to the United States district attorney, and under his supervision a map and abstract of title were prepared and forwarded to Washington. When the necessary information is received at this office the survey already authorized will be made, and the boundaries of the property marked with iron monuments. This survey will show that some of the property is of no service to the canal, and that other property along the canal-banks should be in the possession of the Government.

CITY SEWERS EMPTYING INTO THE CANAL.

The city is allowed to empty its sewers into the canal, provided the connections are so made that no solid matter can pass. With two exceptions the law is observed, but if the city does not see the necessity for a change very soon, some means must be adopted to obtain a repeal of the authority. The canal is, at times, very offensive, and will in time become an immense open sewer. It was thought last year that the drains from the paper-mills and other factories might have an injurious effect on the gates and walls, but an analysis of the water shows that at present there is very little danger of such a result.

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CONTRACTS AFFECTING CANAL MANAGEMENT.

When the canal was enlarged, in accordance with a contract with the city of Louisville, a portion of the south bank of the canal was left without the protection of a wall. The city intended building a basin adjacent to the canal, but it is the general opinion that no action will ever be taken in the matter. The wall must be carried across this vacant space before the canal can be considered finished.

A contract between the former management and private parties gave to the latter the right to use canal property and to construct a basin near the railroad bridge, for the purpose of carrying on the coal business. This basin is supposed to be under the control of the superintendent of the canal, but trouble has frequently arisen from a disobedience of his orders.

A portion of the city wharf lies along the south bank of the canal. This wharf is now permanently occupied by coal-boats and steamboats, but previous to the building of the wing-dam on the north side, it was of but little service to the city. When the river is high and the water is running over the wing-dam, the entrance to the canal is difficult, and, unless care is exercised, dangerous. If the control of this portion of the wharf cannot be obtained, the only alternative will be to raise the wing-dam 4 feet.

The city has recently granted permission to private parties to erect a coal-elevator on the canal at the foot of Seventh street. This matter has been placed in the hands of United States district attorney.

DREDGING DEPARTMENT.

The tow-boat, dredges, and mud-scows were old and in very poor condition when received with the canal. Constant repairs have been necessary, and it would have been more economical to have built new boats 18 months ago, but no funds were available for the purpose.

Notwithstanding their condition, the dredges, &c., have done valuable service, and have succeeded in keeping the canal open during the past year. Two of the mud-scows have been enlarged and thoroughly repaired, and the timber for a third is on hand. All the work has been done by our own employés.

Extensive repairs of the tow-boat have been commenced and a new hull is nearly completed. Complete repairs of dredges must be commenced as soon as possible.

The following remarks upon the

STAGES OF THE RIVER AND SEDIMENT DEPOSITED

will show the necessity of keeping the dredging apparatus in perfect order.

During December, 1874, the water rose rapidly, and at the beginning of the year 1875 there was a favorable stage of water in the canal. From the 3d to the 6th of January the water was over the middle gates. During the entire month the weather was very cold, the ice in the canal being at times 1 foot thick. During a portion of this time navigation was kept up by means of an improvised ice-breaker. The water remained high, and on the 28th of February again flooded the middle gates, giving navigable water on the falls. This stage of the river continued until March 26, when boats were again compelled to use the canal. During this high water the deposit in the upper end of the canal was about 2 feet in depth and the deposit in the locks was enormous.

The dredges worked day and night, and as the river fell slowly they succeeded in preventing any delays. The extreme variation of the water-level in the canal during this month was nearly 6 feet. During April, May, and June the stage of the river was very favorable for the canal, but in July it commenced to rise, and by the 7th of August the reading of the gauge above the locks was 30.3 feet, and at the gauge below the locks 55.0 feet. This was the highest stage of water ever known in August, and 5 feet higher than the usual spring-floods. When the river commenced falling it went down very rapidly, receding as much as 6 feet in twenty-four hours and 20 feet in one week. The deposit left by this rise was enormous. Careful measurements gave the following amounts: In new locks, 20,629 cubic yards, being 11 feet in depth; in old locks, 9,000 cubic yards, filling lower chambers; in canal, 24,000 cubic yards; making a total of 53,629 cubic yards in the canal and locks. The dredges immediately commenced working day and night, but the river fell so rapidly that on the 17th lockages had to be suspended, but by the 20th they were resumed. During the three days the locks could not be used, fortunately but few boats desired to pass through.

During September and October the river remained at a good stage for light-draught boats, but toward the latter part of November the usual rise commenced, and on the 29th the water was level with the top of the middle gates. December 1 the river fell slightly, and during the remainder of the month the water has been at a favorable stage for the canal. Much sediment has been left in the canal, but constant dredging and an abundance of water have prevented any delays. Several methods have been

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proposed for either preventing these enormous deposits or facilitating their removal, but the only method so far promising certain success is the one now in use. A movable dam at the head of the canal which will permit a strong current to be occasionally established will be an auxiliary to the dredges, but cannot take their place.

TIME OF LOCKAGE.

During the past year records have been kept to determine the time occupied in lockages. It varies so with different stages of water, that only an average can be given.

When the usual force of men are employed and both chambers are used, a lockage will occupy about an hour, or if the water is high and only one chamber is used, half an hour is sufficient.

With an extra force of men the time through 2 chambers can be reduced to 45 minutes. The opening or closing of each gate occupies 7 minutes, and the rest of the time is required for filling and emptying the chambers.

When the canal is clear and only being used by steamboats, the time of one lockage will give the means of computing the daily capacity of the locks; but when the canal is being used by tows, there are so many delays entirely beyond the control of the superintendent that no computation can be made.

On December 3 it took 5 hours and 45 minutes to pass the steamer Sam Brown and 16 boats, carrying about 10,700 tons of coal. But one lock-chamber was used, and, from the size of the boats, 6 lockages were necessary. Not more than 3 hours were consumed in moving gates and filling and emptying chambers, so that 2¾ hours were required for moving the boats into and out of the locks.

Frequently there are as many as 4 or 5 tows, with from 15 to 20 boats each, waiting to pass down through the canal, and, at the same time, passenger-boats and upward-bound tows are pressing their claims. Tows cannot pass each other except at the head or the foot of the canal, and ordinarily they can only pass steamboats at one intermediate point.

From the above it will be seen that with the best of management and perfection in the movements of boats, occasional delays are unavoidable.

But the movement of boats is far from perfection. Large tows have small and frequently a very inefficient set of hands; it takes them a long time to arrange their boats and move through the canal, and often after reaching the locks no means are provided for removing the boats as they are passed through. If it is foggy, or if there is much wind, coal-boats cannot be moved, and must be held in the basin at the head of the locks. It thus happens that, at times, hours and even whole nights are lost, when it is very important that the boats should keep moving, clearing the way for those coming behind them.

During the past year extra forces have been employed whenever a pressure of work demanded it, and the lock-hands have been on hand day and night, ready for any boat that wished to pass through the canal.

SUSPENSION OF NAVIGATION BY HIGH WATER, ICE, ETC.

During the past year the canal has been in a navigable condition 272 days and closed 93 days, the latter time being divided as follows:

Closed by ice 35 days. During this time a few boats passed, but navigation was virtually suspended.

Closed by high water 54 days. During this time boats could use the falls, and the canal was not needed.

Closed for repairs and dredging 4 days. During this time but few boats wished to pass through.

During the year there have been but 68 days when there was less than 5 feet of water in the canal, and but 23 days when there was less than 4 feet.

NUMBER, DESIGNATION, AND MONTHLY PAY OF EMPLOYÉS.

The following employés have been necessary for the superintendence, management, and repair of the canal and accessories during the past year. The number of salaries are the same as during the first six months' management. The number is the same as employed before the Government assumed charge, and the salaries are the same with the exception of that of assistant superintendent, which formerly was $250 per month.

For general superintendence.

One superintendent, per month	$250 00
One assistant superintendent, per month	150 00

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For collection of tolls and clerical work.

One toll-collector, per month	$150 00

For manœuvering gates, turning bridges, &c.

One lock-master, per month	$95 00
One assistant lock-master, per month	70 00
Twenty-two lock-hands, per month, each	50 00
Two lock-hands and divers, per month, each	60 00
One watchman, per month	50 00
One bridge-tender, per month	30 00

For repairs of boats, gates, machinery, &c.

One carpenter, per month	$85 00
One assistant carpenter, per month	60 00
One blacksmith, per month	80 00
One blacksmith's striker, per month	30 00

The above forces work day and night without extra pay. The lock-forces are not worked in reliefs, as all are required for opening and closing the gates.

When the locks are in constant operation day and night for any length of time, a few extra men are employed at the same rates as the regular employés.

For management of tow-boat.

One captain and pilot, per month	$80 00
One engineer, per month	80 00
Three deck-hands and firemen, each, per month	40 00
One watchman, per month	40 00

For management of two dredges and four mud-scows.

One foreman of dredges, per month	$80 00
Two engineers, per month, each	80 00
Two dipper-tenders, per month, each	50 00
Six deck-hands, per month, each	40 00
Two firemen, per month, each	40 00
One watchman, per month	40 00

The steamboat and dredge hands work during daylight and Sundays, if required; for night-work they receive proportional extra pay.

The monthly cost of the above labor, when only the regular force is employed and there is no night-work, is $3,330.

During the past year the cost of extra labor has been $545.57, and of night-work $633.18.

The engineers and some other employés on the steamboat and dredges have been performing their present duties for a long time. They are receiving less for their services than is paid for the same class of work elsewhere, and to retain them a small increase may be necessary.

The superintendent, assistant superintendent, and collector of tolls, in addition to their usual work, performed the duties of assistant engineer, overseer, and clerk on the work being done for the improvement of the Falls of the Ohio.

RATES OF TOLL AND CHARGES FOR DRY-DOCK.

The rates of toll charged during the past year have been as follows:

Steamboats, 10 cents per ton registered under-tonnage.

Model barges, 10 cents per ton registered under-tonnage.

Coal-boats, flats, &c., 8 cents per ton, measured capacity.

Steamboats of less than 50 tons and flats of less than 63 tons, $5.

Rafts of logs, &c., measurement and rates the same as for coal-boats, &c.

Boats belonging to the United States, free.

Use of dry-dock, $75 per week.

The above rates on steamboats are the same as fixed by Congress May 11, 1874; the rates on coal-boats were increased from 5 cents to 8 cents by the Secretary of War last January, in order to make the rates more uniform. This small increase, which has

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hardly been felt, has increasad the yearly receipts $16,297.96. The custom-house measurement is taken for all boats having registers, and the total tonnage of such boats being about double their under-tonnage, the rate is, in reality, about 5 cents per ton, carrying-capacity. Coal-boats, flat-boats, &c., are measured and their under-tonnage computed. This class of boats will carry about one and one-half times the amount indicated by their measured under-tonnage, so that the rate for their carrying-capacity is about the same as for steamboats and model barges.

Examples.

Class.	Total tonnage, or carrying-capacity.	Under-tonnage, or tonnage charged for.
Steamer Mountaineer	585. 66	358. 81
Steamer Mary Alice	559. 56	348. 73
Model barge Mary	706. 60	362. 53
Model barge, Mississippi Transportation Company, No. 51	1, 012. 30	417. 16
Square barge, 130 by 24 by 7½	480. 00	246. 00

At the present rate, the tolls will amount to about ⅛ cent per bushel of coal, ⅓ cent per barrel of salt, and 6 cents per ton of iron-ore.

The following examples will show the great reduction in tolls under the Government management:

Class.	Name.	Under-tonnage.	Charges under old management.	Present charges.
Steamboat	Thompson Dean	996	$498 00	$99 60
Do	Thos. Sherlock	877	438 00	87 70
Model barge	Rubicon	390	195 00	39 00
Square barge	130 by 25 by 7	239	65 00	19 12
Produce-boat	100 by 20 by 5	105	60 00	8 40

Under the former management a distinction was made between loaded and empty barges; and I think such an arrangement of tolls would be more satisfactory than the present system of charging a uniform rate.

EXPENSES OF SUPERINTENDENCE, MANAGEMENT, AND REPAIRS, AND RECEIPTS FROM TOLLS, &C., DURING THE YEAR ENDING DECEMBER 31, 1875.

The total expenditure during the past year has been $49,759.48. Deducting $3,192.61 for permanent work and not chargeable to yearly expenses, the cost of operating the canal has been $46,566.87. The cost of the same work, from June 11, 1874, to December 31, 1874, was $25,142.11, or at the rate of $44,986.25 per year.

The receipts, from June 11, 1874, to December 31, 1874, were $20,395.53, being $4,746.58 less than the operating expenses.

The receipts during the past year have been $70,175.61, being $20,416.13 in excess of the expenditures.

The following table will show the comparative monthly receipts and expenditures for the past year. The expenses are given for the months in which they were incurred, and the statement will therefore not exactly agree with a cash statement of receipts and disbursements.

Month.	Collections.	Expenses.	Deficit.	Surplus.
January	$3, 015 25	$3, 760 58	$745 33	.....
February	2, 092 40	3, 527 88	1, 435 48	.....
March	1, 525 76	3, 856 28	2, 330 52	.....
April	10, 277 44	4, 045 84	.....	$6, 231 60
May	12, 935 48	3, 872 40	.....	9, 063 08
June	7, 447 07	4, 172 83	.....	3, 274 24
July	2, 864 96	3, 817 32	952 36	.....
August	3, 406 81	3, 985 80	578 99	.....
September	3, 715 86	4, 173 75	457 89	.....
October	3, 289 32	3, 782 09	492 77	.....
November	8, 225 00	4, 299 77	.....	3, 925 23
December	11, 380 26	6, 464 94	.....	4, 915 32

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It will be seen from this exhibit that during seven months of the year the expenses exceeded the receipts $6,993.34, and during five months the receipts were in excess of the expenses $27,409.47. After deducting the deficit of last year, a balance is left of $15,669.55.

The period from June 11, 1874, to December 31, 1874, was very unfavorable for navigation, the water being low 150 days out of 204. On the other hand, the present year has been favorable, there being but 23 days when there was 4 feet and less, and but 61 days when boats could use the falls. During August, September, and October of this year, usually low-water months, the river was high and navigation lively.

The principal income of the canal is from boats carrying coal from Pittsburgh, salt from the Kanawha, and iron-ore from Missouri and the Tennessee River.

The boats of this description passing through the canal during the past year have been as follows:

Coal-boats carrying about 7,866,650 bushels of coal.

Barges carrying about 60,000 barrels salt.

Barges carrying about 79,177 tons iron-ore.

These coal-boats start upon a rising river, and generally reach Louisville in about 5 or 6 days. If there is sufficient water they pass over the falls, and the whole income from this source is lost.

During last August most of the coal-tows passed over the falls safely, but during November and December the stage of the river necessitated the use of the canal. Had there been 1 foot more water all the canal-boats, which added about $5,500 to the yearly receipts, would have passed over the falls.

These facts, as well as the following comparisons of tonnage through the canal during the latter halves of the years 1874 and 1875, will show that no very accurate estimate of receipts can be made until the business of several years can be compared.

Tonnage.	July.	August.	September.	October.	November.	December.
1874	16,204	45,970	14,395	16,999	21,989	121,278
1875	29,036	35,950	36,587	30,824	39,061	130,074

Judging from past experience, and supposing that the coming year will be an average of the two past, the present rate of tolls will secure a sufficient income for the superintendence, management, and ordinary repairs, and will give a small surplus. But as gates, boats, &c., are perishable, every few years a larger outlay than usual will be necessary, and the expenses of the past year cannot be taken as a sample for all years to come. The necessary work projected for next year will absorb all the surplus now on hand, all that may be gained during the coming year, and then not be completed.

A more detailed statement of receipts is annexed to this report.

The great number of boats, and the amount of the tonnage, which, it must be remembered, is far below the carrying-capacity, will show how greatly commerce has been benefited by the enlargement of the canal.

A detailed statement of the expenses is also appended. These expenses are divided between lockage department, dredging department, and permanent improvements. The item of repairs in both departments is very large, and this expense might have been reduced had sufficient funds been available 12 or 18 months ago for rebuilding worn-out boats, &c., rather than resorting to constant patchwork.

It will be seen that the expense of removing the river-deposit has been more than one-third of the operating expenses of the canal, and this deposit not only entails the expense of removing it, but adds immensely to the difficulties of opening and closing the gates, and renders necessary the large force employed upon the locks.

In fact, the expenses of managing this canal cannot be compared with the expenses of other canals, for there is none in this country, or in the world, in which the gates are so large and so heavy, and where, at the same time, a single freshet will almost fill the lock-chamber with sediment.

WORK ACCOMPLISHED DURING PAST YEAR BY EMPLOYÉS, STEAMBOAT, DREDGES, &C.

In addition to constant repairs to boats, gates, bridges, buildings, tools, &c., the mechanics have built and made one carpenter-shop, 20 by 50, and shed, 15 by 50; two watch-houses for old locks; two mud-scows, 22 by 50 by 6, with a capacity of 38 cubic yards each; one spud and one dipper-handle for dredges; one hoisting-chain 185 feet long, and one turn-table chain for dredges; four pinions and sheeves for dredges; four gate-chains for new locks, total length 464 feet; two friction-rollers for well-holes of new locks.

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The lock-hands, in addition to grading and repairing slopes and general work around buildings and grounds, have passed through the locks 2,280 vessels, requiring 1,401 lockages. They have opened and closed the gates 8,406 times, and merely in turning the capstans and moving from one gate to another each man has traveled about 2,604.85 miles, or an average of 7.14 miles per day.

The steamboat and dredges have worked 215 days during the year, and have removed 90,488 cubic yards of sediment. The tow-boat, while towing out the scows, has run 1,863.5 miles.

The office-work has been as follows:

The superintendent, in addition to his regular duties, has prepared all plans, &c., for gates, boats, shops, &c.

The collector of tolls has, in addition to his regular duties of collecting and depositing tolls, performed the duties of clerk, kept the records of the office, and made the various reports required.

Daily readings of gauges have been taken above and below the locks, for the purpose of comparing the relative variation in the water-level above and below the falls. Records have been kept of the rise and fall of the water at characteristic points of the river, in order to determine the time rises in the upper rivers will reach Louisville, and predict what stage of water may be expected in the canal.

Samples of the river-water have been collected daily to determine the amount of sediment it contains.

The canal-water and the emptyings of the city sewers have been analyzed to determine whether any injury to the iron and wood of the gates and to the walls may be expected from these sources.

In addition to the canal-work, all estimates and clerical work pertaining to the "improvement of the Falls of the Ohio" have been attended to in this office.

WORK PROJECTED FOR THE COMING YEAR, WITH ESTIMATE OF COST.

The following necessary work should be done during the coming year, or at least so much of it as the means made available will permit.

Management, superintendence, &c., of canal.

Pay-roll of employés	$39,960 00
Extra pay and night-work	1,178 75
Ordinary repairs, purchases, &c	5,428 12
Total	46,566 87

Two new mud-scows	$883 29
Guard-gates at head of canal	8,000 00
Guard-gates at new locks	16,000 00
Repairing tow-boat	7,303 85
Repairing two dredges	8,000 00
Two sets of gates for old locks	6,000 00
Applying horse-power at new locks	3,000 00
Office for superintendent	800 00
Cistern and additional fire-apparatus	2,000 00
Telegraph between head and foot of canal	500 00
Survey of land and marking boundaries	1,000 00
Raising masonry around gate-recesses of middle gates of new locks	5,000 00
Repairing miter-sills of old locks	600 00
Machinery, lathe, saw, &c	1,000 00
Total	60,087 14

NECESSITIES FOR A SURPLUS-FUND.

The preceding recapitulation of work shows the immediate necessity for a fund with which all the accessories of the canal can be placed in a perfect condition. Some of this work is of a permanent nature, while other portions will again require attention in a few years. The report upon the condition of the canal shows much work, such as repairing, coping, and miter-sills of new locks, adding side-culverts for filling chambers, new wall on north bank of canal, completing wall on the south bank, rebuilding old locks, enlarging dry-dock, &c., which, though not of immediate necessity, must have attention in the future.

An increased commerce may require further enlargements, &c.

If all such work is to be paid for by appropriation, a surplus-fund which will insure the payment of employés during dull months and provide for accidents is sufficient, but if the canal is to be self-sustaining a large fund must be allowed to accumulate.

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CONCLUSION AND RECOMMENDATIONS.

In my opinion a still longer time should be allowed before deciding definitely upon the future management. The present condition of the canal requires a certain system, but when the work recommended is carried out, the condition will be somewhat changed, and it is possible that in the future the management can be simplified, the expenses reduced, and the efficiency of the canal still preserved.

I would respectfully recommend that for the following year the present system of superintendence and management be continued.

I would also recommend that the present rate of tolls be continued with the following exceptions: That all barges and flat-boats passing through the canal loaded, shall, when returning empty, be charged but 5 cents per ton. This will slightly reduce the receipts, but I think the change will make the rates more just, and will be gladly welcomed by the boating interests.

I would respectfully suggest that Congress be asked for a loan of $50,000, which, with the surplus now on hand, will complete the much-needed repairs previously referred to.

I would respectfully suggest that the question of jurisdiction at the head of the canal be investigated and a legal opinion given as to the rights of the superintendent in case in his opinion the occupancy of the wharf interferes with navigation or renders it difficult or dangerous. When an occasion arises requiring action, life and property may be at stake and there would be no time for prolonged legal action.

I would respectfully suggest that the surveyors of customs measuring and remeasuring vessels liable to use the Louisville and Portland Canal be again requested to furnish the result of said measurement to the collector of tolls. Lists of boats registered in the different districts have frequently been asked for, and but few have been received.

I would respectfully recommend that, if possible, the time for reporting upon receipts and expenditures, fixed by section 3, act of May 11, 1874, be so changed as to allow more time between the close of the year and the report. The first Monday in January was evidently selected on account of its being the day upon which annual meetings of the former management were held. But these meetings were held in Louisville and all required information could easily be prepared in the time allowed; now that the reports must go to Washington, the time is not sufficient.

I would respectfully suggest that some action be taken as soon as possible upon the rebuilding of the old locks and the enlargement of the dry-dock. It is almost a waste of money to patch up the old locks; but if no action is taken, certain repairs must be made. The question of enlarging the dry-dock is more one of policy than of engineering, but the advantages to the boating interests are so evident, that I have no hesitation in recommending it.

I would respectfully urge the necessity of action upon the rules and regulations proposed in the report of last December, and again appended to this report. If adopted, instructions should be given as to how they are to be enforced. To manage the canal properly, and deal justly with the various parties using it, requires prompt action in case of disputes, &c.; and if the superintendent is to be held responsible for delays, he must have the power to enforce his orders, and must be able to exercise this power without going into long legal proceedings.

In conclusion, I would state that the superintendent, assistant superintendent, toll-collector, and all other employés, deserve great credit for the faithful and fearless manner in which they have performed their duties during the past year. By intelligence, energy, ingenuity, and strict attention to duty, they have overcome many difficulties, and have preserved the canal in a high state of efficiency.

Dealing justice to all has occasionally brought forth complaints, but in no instance have such complaints been founded on facts.

I am, very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

Major G. WEITZEL,
Corps of Engineers, U. S. A.

RULES AND REGULATIONS FOR THE GOVERNMENT OF THE LOUISVILLE AND PORTLAND CANAL, AND THOSE USING IT.

1. The movement of all boats and floating things in the canal and the locks shall be under the direction of the superintendent or his authorizeds sistants.

2. When two or more boats or tows are waiting to enter the canal, either from above or from below, the superintendent shall have authority to designate the time and order of their entering; and no boats or tows shall enter the canal without his authority.

3. No boat shall tie up along the bank of the canal, or in any way obstruct the canal, or delay entering or leaving the locks when ordered to do so by proper authority.

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4. All boats meeting in the canal shall pass to the right; and when the passage is too narrow, the ascending boat shall move into a turn-out basin, unless the descending boat is much nearer to it.

5. Ordinarily boats and tows, arriving first at the locks, shall have the preference in passing; but in all cases, boats and barges belonging to the United States, and employed upon the work, shall have the precedence over all others; and steam or passenger boats shall have the precedence over heavy tows; and loaded tows shall have the precedence over empty tows.

6. No boat shall run alongside of any other boat so as to wedge in the canal, nor shall any boat, when approaching the locks, attempt to pass another boat when within 800 feet of the locks.

7. No boat shall enter the canal or the locks whose actual draught exceeds the depth of the water in the canal, as shown by the gauge at the head.

8. All boats waiting for lockage must be kept in the basin above the locks, or beyond the breast-wall below the locks, and not in any way obstruct the channel until their time comes for entering the locks.

9. All boats, &c., arriving at the locks and not taking advantage of the first opportunity to pass shall lose their turn.

10. Any unnecessary delay in the locks or the canal, or the violation of any lawful order of the superintendent, shall be construed as obstructing the free navigation of the canal.

11. All boats, when in the locks, shall fasten their bow and stern lines to the straps or snubbing-posts on the walls or banks of the locks until the chamber is filled or emptied. They shall also be provided with fenders, to be used when striking any part of the locks.

12. No boat shall strike any bridge, gate, breast-wall, stay-chain, or any part of the locks liable to be injured.

13. All boats using the canal shall be free from projecting irons or rough surfaces that would be liable to damage the walls or any part of the canal or locks.

14. The under-tonnage of all boats shall be determined by the custom-house measurement if registered, and if not registered, by the measurement of the collector of tolls.

15. All tolls shall be paid in lawful currency of the United States, and no boat shall be allowed to leave the locks until the toll is paid.

16. In no case shall the tolls collected from any boat be less than the actual expenses of operating the locks.

17. That any one who shall willfully, or through carelessness, in any way obstruct the free navigation of the canal, or by the violation of any of the laws or regulations governing the canal and those using it, delay or inconvenience any boat having the right to use the canal, shall be responsible for all damages and delays and for all expenses of removing the obstructions.

18. No one shall trespass upon the canal property, or in any way injure the canal, the locks, or any of the appendages.

19. No one, unless authorized by the superintendent or the lock-master, shall open or close any gate or wicket, or in any way interfere with the employés in the discharge of their duties.

20. No person shall throw or roll any stone or other material into the canal, or place any such material on any bank or berm of the canal so that it is liable to be thrown or rolled in.

21. All boats approaching the locks shall signal for the same by four distinct whistles.

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Statement of number of steamboats, model barges, coal-boats, &c., passed through the Louisville and Portland Canal during year ending December 31, 1875, and receipts from tolls, &c.

Month.	Steamboats.	Tow-boats.	Model barges.	Square barges.	Small boats.	Tonnage.
January	19	18	22	70	2	42,949½
February	24	7	13	22	4	21,256½
March	10	7	13	28	6	15,509½
April	60	44	94	203	10	111,562½
May	86	51	129	214	4	140,307½
June	77	33	78	74	6	74,578
July	32	14	25	31	1	29,036
August	28	22	34	62	1	35,950
September	84	17	34	49	7	36,587
October	97	11	26	36	20	30,824
November	73	33	78	212	25	89,061
December	57	24	47	269	4	130,074
Total	647	281	593	1,270	90	757,695½

Receipts from tolls	$68,664 75
Receipts from dry dock	599 21
Receipts from rents	561 65
Receipts from towage	350 00
Total	70,175 61

NOTE.—Rate of toll on model and square barges was changed from 5 cents per ton to 10 cents and 8 cents, respectively, January 25, 1875. Steamboats and model barges less than 50 tons, and square barges less than 63 tons, are charged $5 for lockage.

Statement of expenses of superintendence, management, repair, and improvement of the Louisville and Portland Canal and its accessories for the year ending December 31, 1875.

Months.	Lockage department.			Dredge department.			Improvements.	Total expenses.
	Labor.	Repairs, lights, &c.	Total.	Labor.	Repairs, fuel, oil, &c.	Total.		
January	$2,310 00	$135 36	$2,445 36	$1,045 00	$270 22	$1,315 22	.....	$3,760 58
February	2,310 00	108 05	2,418 05	1,020 00	89 83	1,109 83	.....	3,527 88
March	2,350 00	62 13	2,412 13	1,020 00	399 35	1,419 35	$24 80	3,856 28
April	2,315 32	98 97	2,414 29	1,082 67	459 53	1,542 20	89 35	4,045 84
May	2,310 00	73 31	2,383 31	1,020 00	330 16	1,350 16	138 93	3,872 40
June	2,310 00	63 83	2,373 83	1,020 00	231 20	1,251 20	547 80	4,172 83
July	2,310 00	77 34	2,387 34	1,020 00	341 08	1,361 08	68 90	3,817 32
August	2,310 00	119 64	2,429 64	1,202 00	274 41	1,476 41	79 75	3,985 80
September	2,310 00	82 00	2,392 00	1,383 51	317 23	1,700 74	81 01	4,173 75
October	2,321 67	90 29	2,411 96	1,020 00	342 48	1,362 48	7 65	3,782 09
November	2,605 75	217 90	2,823 65	1,020 00	391 82	1,411 82	64 30	4,299 77
December	2,502 83	98 52	2,601 35	1,020 00	753 47	1,773 47	2,090 12	6,464 94
Total	28,265 57	1,227 34	29,492 91	12,873 18	4,200 78	17,073 96	3,192 61	49,759 48

NOTE.—The expenses in the above table are charged to the months in which they were incurred, and consequently will not agree with the financial statement. Under the head of improvements are classed such repairs and improvements as are of a permanent character, if not properly chargeable to annual operating expenses.

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